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PRESIDENT'S MESSAGE - LOUISIANA DIVISION

Jackie Theriot
President, Louisiana Division
American Society of Sugar Cane Technologists

The "mother of all freezes" is hopefully one we will not experience in Louisiana for another 100 years. As last year's president of the ASSCT-La. Div. indicated in his message, the coldest temperature recorded was 8.9 degree F. The continuous freezing temperature lasted for a record 80 hours. Ice could be detected at a 4 inch depth in the soil.

The loss from the December, 1989 freeze is now recorded history. Louisiana produced 4,648,384 tons of sugar cane during the 1990 harvest. The harvest of 1989 produced 8,329,310 tons of sugar cane. Total sugar produced in 1990 is 432,297 tons as compared to 1989 at 842,094. In 1990, 192,000 acres of sugar cane was harvested as opposed to 299,000 in 1989. The total monetary loss to the economy amounted to nearly $200,000,000 to the growers, processors, and landlords.

It has been decades since a factory did not operate in Louisiana for a season due to climatic conditions. However, after several weeks of pessimistic reports on the condition of the crop due to the freeze, two cooperative factories in the western area of the sugar cane belt agreed to harvest together at one factory. This decision proved to be a wise choice for the farmers and may enhance possible mergers in the future.

When one draws a line representing the snowfall in Louisiana during December of 1989, it is obvious that the snowfall had an insulating effect on the sugar cane stubble. South of the snowfall line an average of 75 percent of a normal crop was harvested. North of this line the average harvested dropped to 47 percent in the western region and 44 percent in the eastern region of the cane belt. As much as 72 percent of the crop was lost at certain factories.

With the S&L, FmHA, and private bank problems, liberal credit has disappeared. Many growers in Louisiana have experienced problems in receiving the necessary funds for their 1991 crop. The pendulum has swung from a liberal "sign on the dotted line" for funding to the conservative attitude that if one cannot cashflow by 110 percent then certain refusal will be the outcome. Unfortunately, many farmers have experienced a delay in acquiring necessary funding.

As prices hover in the 21 cent range, the continued question of whether or not there was too much sugar imported into this country is being answered daily. MSP level has not been reached for a number of weeks now. Whether the appointment of Edward Madigan as the new Secretary of Agriculture will have any impact is yet to be experienced.

He was one of 91 members of the House to vote against the farm bill because it strayed too far from the 1985 farm bill's market-oriented policies.

As we approach the 21st century environment has become a foremost concern of the citizens of this country. That is good! In remembering that we were placed on this planet to provide for the propagation of future generations our society will have to devote more time, effort, and money to the environmental problems. The sugar cane industry must bear a fair share of these concerns. The sugar cane industry in Florida has taken the lead in realizing that necessary steps must be mandated to assist in a continuation of that industry. Albeit the serious implications regarding thousands of acres of sugar cane land, the industry will have to continue to police itself due to the problems of Lake Okechobee and the Everglades.

In Louisiana, we are in the midst of tighter controls in regards to air and water quality. An environmental committee has been in place for a few weeks now within the American Sugar Cane

League. As a standing committee it is working to protect the environment while maximizing the efficiency of the Louisiana sugar industry. By strengthening existing technologies and developing improved strategies, Louisiana's natural resources of air, water, and soil can be protected for the public as well as for future generations of sugar cane producers and processors. The goal of the committee is to achieve a balance between maximum productivity and a healthy environment by working through governmental agencies, legislative bodies and researchers. This group will also work to provide adequate data on which to base future legislation regulating practices that affect the environment and will work directly with state and federal environmental agencies in their efforts to protect the natural resources of Louisiana.

Some in our industry have expressed concerns that environmental policies are too strict because costs outweigh benefits--or too lax because the benefits of stricter controls exceed the costs. The debate goes on in large part because so little is known about the magnitude of the beneficial effects of pollution control policies. We should not propose to settle the debate by providing a measure of these benefits. That is not the answer! Most of us understand that excessive pollution is occurring throughout the world. Scientists, with data from satellites, have come to the conclusion that the necessary ozone layer in the upper atmosphere has been reduced by 5 percent since 1973, double the rate they suspected prior to satellite transmissions presently being forwarded to our laboratories. Prudence requires us to get our heads just a little further out of the sand and go after some solid answers. One thing that is certain: environmental pressures are just beginning. State and local governments and certain business leaders are responding to this pressure, not just reactively, but aggressively seeking opportunities to act as social catalysts.

The shift to an environmental civilization will not be easy, fast, or cheap. But there is growing national consensus that it must happen. People are embracing a new consciousness, a new vision of reality, a new sense of their place in nature.

Our increased productivity and the application of new technology to problems in the sugar cane industry will have to spill over into the environmental arena. By-products and "waste products" will find new names as "recyclable materials," "soil additives," and "compost aggregates." Some of our flyash is being tested on oil field pits for reclaiming soils. Experimentation with filter cake, flyash, bagasse, and water absorbing crystals could be a new material for golf greens to stabilize color and reduce irrigation.

Scientists at LSU are presently applying for a patent on a pressurized chamber which converts filter cake, under pressure with an infusion of ammonia, to a desirable soil additive with a 6 percent nitrogen content, along with other available nutrients such as potassium and phosphorous.

Audubon Sugar Institute is involved with sugar cane in the environmental area. The general goals and objectives of the Institute are:

- *to initiate a long term environmental control project for the sugar factories within the state of Louisiana.
- *to enhance the understanding of environmental concerns and needs of the sugar industry.
- *to categorize the factories by land and/or water usage and/or cane processed and prioritize them based on environmental problems.

According to scientists at LSU, it is estimated that up to six pounds of sugar per ton of sugar cane can be lost into the cane wash water. If cane is to be washed as currently practiced, this type of loss and waste problem cannot be avoided. Nonetheless, chemical treatment of the wash water to maintain Ph or reduce odor is unsatisfactory. The best answer will come from good biological control of the pond system. Therefore, our industry will need to evaluate the use of biologically engineered micro-organisms to satisfy the environment.

The Hawaiian Sugar Planter's Association report an acre of growing sugar cane produces and releases into the atmosphere 60 tons of oxygen and removes 96 tons of carbon dioxide over a two-year period. When an acre of sugar cane is burned, it adds about 10 to 15 tons of carbon dioxide and a half ton carbon monoxide into the atmosphere, and consumes about one ton of oxygen during the fire. Sugar cane has the ability to trap and absorb ozone, sulfur dioxide, and carbon monoxide, helping to cleanse the air of these unwanted pollutants. Further, the aesthetic value and the soil conservation sugar cane provides through its growth year round enhances all human beings in the area.

For scientists, the environment has always been viewed as a composite of natural and physical structures exhibiting a complex variety of linkages, although even they did not have a clear understanding of the extent of these relationships until recently. Now average citizens are becoming aware that the environment is something more than wilderness areas and streams. Rather, a significant number of these citizens have also begun to view their total surroundings as a complex ecosystem with a wide range of interrelated plant and animal species existing within a diverse and comprehensive global environment.

The linking of agricultural policy goals and environmental policy aims is certain to be expanded during the next few years.

The Conservation Reserve Program, sodbuster/swampbuster restrictions, the 1990 conservation compliance requirement, and the use of conservation easements in restructuring Farmer's Home Administration loans have become a reality for our American farmers.

Despite some problems in the interpretation and implementation of those measures, they represent a realistic approach to lessening the potential adverse impact of agriculture on the environment. We all realize that the wetlands issue is of serious concern to Louisiana and Florida. Furthermore, this issue has been over-administered and over-regulated in interpretations coming from Washington. The classical example is of a woman who was fined $10,000 for planting some roses in a wetland area without getting the necessary permit(s).

The climate for debate on environmental issues is headed toward a fever-pitch level. Public concern about the quality of our environment is on the rise. And it's not just environmental groups that are concerned. So are most farm-related organizations and, more importantly, individual farmers. No one knows better than the farmer that issues such as global warming, depletion of the ozone layer, ground water contamination, and pesticide runoff pose problems for future agricultural prosperity. The question frequently asked is: "How can we best minimize any possible harmful effects to the environment from farming?"

Most experts agree that pesticides, when properly used, are safe to both people and the environment. Clearly, pesticides are important tools for American agriculture. But we must be cognizant of any adverse impact they may have on human health or the environment, and we must be prepared to correct those problems.

At the same time that food safety concerns are on the rise, the average life expectancy for Americans is also increasing, and now stands at 74.9 years. We must be doing something right.

Referring to the public's concern about the contamination of groundwater, most research is need, along with integrated pest management and other systems that would minimize any problems from agriculture. It's hardly any feat, with today's sophisticated analytical technology, to find pesticides in groundwater. Generally, the quantities are so small as to be totally inconsequential in terms of health concerns. Still, a public bombarded by media scare stories is concerned that its water is being poisoned. New technology is taking us further than we ever though possible. Even though we can measure it, we simply don't fully understand what it means to ingest one part per billion of a particular residue over the span of 70 years in terms of human health. Is it safe? Is it relevant?

We have to balance the needs of protecting farmer income and insuring an adequate supply of food for domestic/export use; on the other hand, we must address this growing public concern about environmental quality and health.

Science must work in an environment which is not controlled by media hype and interference. We cannot allow policy to move ahead of science, nor can we let policy move ahead of common sense.

We must answer the question, "How can we ensure a safe, affordable, and secure supply of food to feed our nation and other nations in the coming century?" This will require an intense effort, with clear insight, and a driving will. We must respond quickly to changing circumstances, taking advantage of change and not being threatened by it.

A constructive strategy for coping with the environmental situation may be expressed in a simple slogan--the TANSTAAFL principle: There Ain't No Such Thing As A Free Lunch. This is closely related to the fundamental theorem of ecological economics, that everything depends on everything else. Or, behind every free lunch there is a hidden cost to be accounted for.

"If we can go to the moon, why can't we eliminate pollution?" Solving the pollution problem is no easier than going to the moon, and therefore requires a comparable effort in terms of people and resources and the same sort of logical hard-headedness that made Apollo a success. Social scientists, politicians, and journalists who spend their time trying to find someone to blame, searching for a magic device or regulation, or complaining about human nature, will be as helpful in solving the pollution problem as they were in getting us to the moon.

Williams Jennings Bryan said it best a century ago, "Destiny is not a matter of chance, it's a matter of choice. It's not something to wait for, it's something to work for."

Nonetheless, in simple terms, despite all our accomplishments, man owes his existence to a six-inch layer of topsoil and the fact that it rains.

PRESIDENT'S MESSAGE - FLORIDA DIVISION

Omelio Sosa, Jr
President, Florida Division
American Society of Sugar Cane Technologists

On behalf of the Florida Division of the American Society of Sugar Cane Technologists, we would like to thank the Louisiana Division for again hosting this meeting in New Orleans, the Twenty-First Annual Joint Meeting. We were treated so well here a couple of years ago, that we wanted to return and enjoy your warm hospitality and the wonderful sights of this great city. This is your "neighborhood," so I do not think meeting here is much of a change for cajuns, but it is for us; again, thanks for having us back.

It is with great pleasure and pride to report to you that the Florida sugar cane industry has just completed a record breaking harvest this season. A total of 15,887,657 short tons of cane were ground, producing 1,805,911 short tons (raw value) of sugar, with a yield of 11.17 percent, from an estimated 420,000 acres harvested for sugar. There were 36 varieties grown commercially which contributed to this record-breaking production year. Based on USDA's estimates, which will have to be revised upward in light of these latest production statistics, Florida's production will amount to 55 percent of all sugar produced from sugar cane, 24 percent of all sugar produced, and 20 percent of all acreage (including sugar beets), in the United States.

Indeed, the Florida sugar cane industry has come a long way. We have had a good year. Overall, we have been blessed with good weather conditions which helped us produce and harvest such a large crop.

Besides all the "old" problems we have had in the past, new ones keep cropping up. Leaf scald is not new, it has been around since the early sixties, but is a disease which is spreading and is of great concern to the industry. Sugar cane rust continues to be a problem. Breeders and plant pathologists work closely to improve varieties with more resistance to sugar cane diseases. We are also trying to breed for leaf pubescence. There is no commercial variety grown in the world that is pubescent. Research indicates that pubescence could be an excellent plant resistant character which can be used against insect pests such as borers and aphids.

We also have a new insect pest, the sugar cane lacebug, just discovered for the first time in Florida last year. This pest is of little importance elsewhere in the world where it occurs, but it is behaving quite destructively on certain varieties in Florida, causing early leaf senescence. We are concerned enough, and efforts are underway, to import a parasite of the lacebug from Venezuela to help us control this pest.

In light of all the problems we face, the importance of research is often overlooked. We have to realize that research and "good old American ingenuity" have brought agriculture to the prominence it now occupies, both in this country and in the world. If we continue neglecting agricultural research, we will not starve tomorrow, but we are bound to feel the consequences in the future. You can have all the bridges, roads, cars, appliances that you want, but you can not eat them. We all recognize (or should) that our American farmers are highly efficient in what they do.

In agricultural research, 10 to 20 years usually pass between the time funds are committed for research and the results are ready for widespread adoption. Think about that. You can not turn research off and five years later turn it on and expect to pick up where you left off. It does not work that way. We have to increase, or at the very least, maintain current levels of research efforts in order to sustain productivity gains over the long run. To give you an example, our budget at the USDA, Agricultural Research Service, Sugar Cane Field Station in Canal Point, has increased a total of 8 percent in 6 years. If you were to take inflation into account, in reality we have lost research dollars. Without ongoing support for research, agricultural productivity is likely to decline. According to a 1985 California Agricultural Lands Project Report, from 1930 to 1980, sugar cane production in the United States experienced a 131 percent increase in production! At least half of this increase has been attributed to new germplasm. Definitely, you reap what you sow; putting it another way, you get what you pay for.

It has not been easy for the sugar industry, it is not easy, and certain forces are constantly trying to make it even more difficult. Some venture to advocate the elimination of the Florida sugar industry. Even more drastic, some foreign interests would like to see the U.S. cease sugar production altogether and thus have the U.S. sugar market all to themselves.

Sugar users "think" they will benefit because they could then buy all that cheap sugar at the so called "world price." ~~Most people~~ (but hopefully none in this room) believe that the world price of sugar is the price at which all sugar is bought or sold in the world market; how wrong they are! People have to realize that in reality there is no free trade of sugar and that there is no world price for sugar. We have to get the message across that most sugar (about 90 percent) traded globally is sold by negotiated agreement at higher prices than the world market and sold at whatever price it brings, and the price it sells for is the so-called "world price of sugar." It is highly unfair to compare U.S. sugar prices to the "world price," like most people do since they know no better.

Do you think for a moment that if the U.S. were to buy all its sugar at the world price, the price of sugar-containing products such as candy bars would fall. I do not think so, but it would certainly mean a lot of money for a lot of people. Historically, when sugar prices have been low, the price of sugar-containing products have not come down. I equate the price of sugar-containing products to a compass. No matter how much you shake or turn it, slowly but surely it always ends up pointing in one direction, that's up or north.

Furthermore, the world sugar market is rarely in equilibrium, and we would have to be prepared to deal with the peak and valley price fluctuations of the world market, and be totally dependent on imports to satisfy our demands. Remember the oil cartel and what happened to the price of oil when a few countries controlled production and price. Incidentally, only 5 countries--Australia, Brazil, Cuba, European Economic Community, and Thailand--now account for 70 percent of world sugar exports. I do not need to tell you what could happen when you are totally dependent on imports, and this goes for any commodity. I hope we never get in that vulnerable position, but I have to remind you, this is what many people advocate in regards to sugar.

One important element of the current sugar program which will be in effect for the next five years is that it provides price stability and availability of sugar supplies. All this at no cost to the government, contrary to popular belief that growers are receiving subsidy from the government, which they are not. We all know this, but we are minuscule section of our society, and as I said earlier, we are constantly under attack. We raise our voices, but so do our adversaries, and I may say, even louder. It is to the credit of public relations advocates that if you keep repeating something over and over and over, even if not true, people will accept it as true, and even your antagonists may mouth your own propaganda and also accept it as fact. We should try to do a better job in keeping the public well informed and knowledgeable about all the facts.

It is true that "united we stand, divided we fall." We are not many, but we should gather our strength from our unity. We have worked very well together in the past. Excellent cooperation between industry, federal, and state institutions have brought us to the spot we now occupy, a prosperous and viable industry. People support many causes and most are good. Reasonable persons tend to support reasonable persons tend to support reasonable causes. However, when some of these causes step on our toes, affect our wallets, and our livelihood, then they cease to be good causes and become a threat.

We all have to be reasonable, we all have to be fair, we all have to communicate, and we all have to be united. In my opinion, if these ingredients are present, we can overcome just about anything.

PEER REFEREED JOURNAL ARTICLES

ITCHGRASS *(ROTTBOELLIA COCHINCHINENSIS)* CONTROL IN SUGARCANE WITH POSTEMERGENCE HERBICIDES[1]

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ABSTRACT

Itchgrass is a major weed pest of sugarcane (*Saccharum* sp.) in Louisiana. This research was conducted to compare alternative herbicide treatments to the asulam standard for postemergence itchgrass control and sugarcane tolerance. In sugarcane fields at two locations, itchgrass populations were significantly reduced with postemergence over-the-top applications of asulam at 3700 g/ha and DPX-V9360 at 18, 34, and 67 g/ha, but not with CGA-136872 at 34 and 67 g/ha. Sugarcane stalk populations compared to asulam were reduced with DPX-V9360 at 18 g/ha at Maringouin, LA (99%) and at Thibodaux, LA (77%), and with CGA-136872 at 34 g/ha only at Maringouin (93%). Sugarcane stalk heights and yields of cane and sugar closely paralleled reductions in stalk populations. Postemergence-directed application of DPX-V9360 injured sugarcane as well. Paraquat at 560 g/ha and ametryn at 2700 g/ha applied postemergence-directed reduced late-season itchgrass infestations by 74 and 52%, respectively, and cane and sugar yields were similar to the asulam standard. Precise management will be required with paraquat use to avoid sugarcane injury.

INTRODUCTION

Itchgrass is of increasing concern to Louisiana growers. Since it was introduced into southern Louisiana in the 1920s (8), it has become a serious weed problem in sugarcane, corn (*Zea mays* L.), and soybean [*Glycine max* (L.) Merr.]. The ability to germinate throughout the growing season and to thrive under a crop canopy makes itchgrass a potentially serious weed problem in most cropping systems (9), requiring intensive weed control efforts. In Louisiana, season-long itchgrass competition reduced sugarcane stalk populations by 34%, and sugarcane and sugar yields by approximately 43% (5). Competition from emergence in May until layby (around June 10) reduced yields comparable to that of season-long competition. Itchgrass emergence after layby, however, did not reduce cane or sugar yields.

Millhollon (6) reported that preemergence treatments of diuron [N′-(3,4-dichlorophenyl)-N,N-dimethylurea], simazine [6-chloro-N,N′-diethyl-1,3,5-triazine-2,4-diamine], fenac (2,3,6-trichlorobenzeneacetic acid), and bromacil [5-bromo-6-methyl-3-(1-methylpropyl)-2,4(1H,3H)pyrimidinedione] applied at layby controlled 63 to 87% of itchgrass. However, postemergence application of DSMA (disodium salt of methylarsonic acid), diuron, dalapon (2,2-dichloropropanoic acid), bromacil, or tank mixtures of TCA (trichloroacetic acid) plus dalapon plus silvex [2-(2,4,5-trichlorophenoxy)propanoic acid] controlled 85 to 97% of itchgrass (6). When applied to 18- to 23-cm itchgrass, 2.6 and 4.5 kg/ha of DSMA controlled 88 and 92% of itchgrass, respectively. Excellent control was also obtained with MSMA (monosodium salt of methylarsonic acid) at 2.8 kg/ha (7). DSMA and MSMA are not registered for use in sugarcane in the U.S. Ametryn [N-ethyl-N'-(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine] is registered for control of itchgrass up to 7.6 cm tall and paraquat [1,1'-dimethyl-4-4'-bipyridinium ion] is currently registered as a postemergence-directed treatment underneath the sugarcane canopy.

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[1] Approved for publication by the Director of the Louisiana Agricultural Experiment Station as manuscript number 90-38-4331.

[2] Reed J. Lencse is a former Graduate Research Assistant and is presently employed with American Cyanamid Company, Lonoke, AR.

Greenhouse and field studies have shown increased efficacy of asulam [methyl[(4-aminophenyl)sulfonyl] carbamate] followed by dalapon or tank mixtures of asulam plus dalapon when compared with using either herbicide alone (3). Millhollon (9) found that itchgrass control was variable (6 to 94%) with postemergence applications of asulam at 3.7 kg/ha. However, a preemergence incorporated application of trifluralin [2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine] at 2.2 kg/ha followed by asulam at 3.7 kg/ha provided 94% itchgrass control and was more consistent than either treatment alone. In Louisiana, a typical itchgrass control program in sugarcane involves band applications of trifluralin preemergence incorporated in the spring with asulam postemergence if needed, and a broadcast application of trifluralin at layby.

Experimental postemergence-herbicides including DPX-V9360 [3-pyridinecarboxamide,2[[[[-dimethoxy-pyrimidin-2-yl)amino-carbonyl]]amino-sulfonyl]]-N,N-dimethyl] marketed under the trade name Accent[3] and CGA-136872 [2-[[[[[4,6-bis(difluoromethyl)-2-pryimidinyl] amino]carbonyl]amino]sulfonyl]benzoic acid methyl ester or] marketed under the trade name Beacon[4] have controlled johnsongrass [*Sorghum halepense* (L.) Pers.] (10, 11) and recently have been labeled for use in corn. These herbicides have shown itchgrass activity as well (2). Paraquat, even though registered for use in sugarcane in Louisiana, is not widely used due to grower concern over cane injury and lack of proper spray delivery systems for postemergence-directed application.

This research was conducted to evaluate DPX-V9360 and CGA-136872 as alternatives to the asulam standard for postemergence over-the-top itchgrass control and cane tolerance. Additionally, postemergence-directed applications of DPX-V9360, paraquat, and ametryn were made to determine their use potential for management of itchgrass.

MATERIALS AND METHODS

Field studies were conducted in 1989 at two locations in the sugarcane growing region of Louisiana. The Pointe Coupee Parish location was near Maringouin, LA in the northern part of the sugarcane growing area and the southern location was in Lafourche Parish near Thibodaux, LA. The sugarcane cultivar 'CP 76-331' was used at the northern location while 'CP 70-321' was present at the southern location. At both locations, sugarcane was planted on raised beds spaced 1.8 m apart and was a second-ratoon crop (third production year).

In the first studies, asulam at 3700 g/ha, DPX-V9360 at 18, 34, and 67 g/ha and CGA-136872 at 34 and 67 g/ha were evaluated. Herbicide treatments were applied to sugarcane 91 cm in height and itchgrass 10 to 31 cm tall at the northern location on May 29. At the southern location, treatments were applied on May 25 to sugarcane 91 cm tall and itchgrass 15 to 30 cm tall. Crop oil concentrate[5] at 1% (v/v) was added to all treatments. Herbicides were applied over-the-top of sugarcane with a tractor-mounted compressed air sprayer delivering 190 l/ha at 207 kPa using a standard three nozzle arrangement, with one nozzle directly over the row and one nozzle on each side of the row on 31 cm drops. The nozzle on either side of the row directed the herbicide spray to the base of the cane stalks to ensure coverage of weeds within the 91-cm treated band. Each plot was

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[3] Accent is a proprietary product of E.I. duPont deNemours & Co., Wilmington, DE 19898.

[4] Beacon is a proprietary product of CIBA-Geigy Corp., Greensboro, NC 27419.

[5] Agridex, containing 83% paraffinic mineral oil and 17% polyoxyethylene sorbitan fatty acid ester, marketed by Helena Chemical Co., 5100 Poplar Ave., Memphis, TN 38137.

5.4 m wide (three sugarcane rows) by 12.2 m long at the northern location and 5.4 m wide by 15.3 m long at the southern location.

Itchgrass control and sugarcane injury were visually rated based on a scale of 0 = no control or crop injury and 100% = complete death. Sugarcane millable stalk populations were determined in mid-August by counting millable stalks (stalks with a height of at least 1.7 m) from the entire plot. Stalk height was determined in mid-August on 12 randomly selected stalks by measuring from the soil surface to the youngest visible dewlap, a structure which is triangular in shape and present on either side of the blade joint of fully-expanded leaves. During this same period, itchgrass populations were determined by counting itchgrass stems with at least two nodes present from a randomly selected 1-m section of the band of each sugarcane row. Sugarcane yields were not determined due to excessive injury.

Additional sugarcane field studies were conducted at the same locations to evaluate postemergence-directed treatments. Herbicides and rates included asulam at 3700 g/ha, DPX-V9360 at 34 g/ha, paraquat at 560 g/ha, and ametryn at 2700 g/ha. Herbicide application dates and crop and weed sizes were the same as those described in the previous study. Nonionic surfactant[6] at 0.25% (v/v) was added to all treatments. A postemergence-directed nozzle arrangement, consisting of one nozzle on each side of the row on 31 cm drops was used to treat a 91-cm band on top of the row. The herbicide spray was directed to the base of the cane stalks (15 cm from the soil surface) to avoid herbicide contact in the whorl of primary and secondary shoots. Weed control and crop injury ratings, sugarcane stalk number and height, and itchgrass density were measured as described for the previous studies.

In addition, entire plots were harvested in the postemergence-directed studies at both locations in late October with a two-row, whole stalk mechanical harvester set to top as close to the first hard internode below the apical meristem as possible. Sugarcane was burned to remove leaves and weeds. Fifteen stalks were randomly removed from each plot, weighed to determine stalk weight, and crushed to determine crusher juice sugar (sucrose) and Brix using standard methods (1). Sugar yield was based on tons of cane per hectare and theoretically recoverable sugar (kg/ton of cane) (4).

A randomized complete block design with four replications was used in all studies. Data were subjected to analysis of variance for individual locations and across locations. Data are presented individually for each location and as an average across locations. Differences among treatment means were determined using Fisher's protected Least Significant Difference (LSD) Test at the 5% level of probability.

RESULTS AND DISCUSSION

Both asulam and DPX-V9360 provided comparable itchgrass control (75 to 87%) when evaluated 16 days after treatment (DAT) but control with CGA-136872 was poor (Table 1). DPX-V9360 and CGA-136872 caused significant sugarcane injury, more so than asulam at both locations. Averaged across locations, significant (46 to 62%) sugarcane injury, evidenced primarily as chlorosis and cane stunting, was noted for all rates of DPX-V9360 and CGA-136872.

Averaged over locations, 67 g/ha DPX-V9360 provided the highest season-long control of itchgrass as evidenced by reductions in itchgrass stem densities in August (Table 2). Asulam and DPX-V9360 at 18 and 34 g/ha did not reduce late-season itchgrass infestation levels when compared to the untreated check. At Maringouin, itchgrass was bunched and stunted with no two-node stems present following treatment with DPX-V9360. However, at the Thibodaux location, small, stunted two-node itchgrass stems were present in the DPX-V9360-treated plots. Itchgrass stems and plants at both locations in the untreated check were tall and robust.

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[6] X-77, Chevron Chemical Co., 575 Market St., San Francisco, CA 94119.

Table 1. Visual itchgrass control and sugarcane injury as influenced by over-the-top herbicide application at Maringouin and Thibodaux, LA, 1989.

Herbicide	Rate	Itchgrass control Maringouin	Itchgrass control Thibodaux	Itchgrass control Average	Sugarcane injury Maringouin	Sugarcane injury Thibodaux	Sugarcane injury Average
	(g/ha)	(%)			(%)		
Asulam	3700	81	75	79	10	20	15
DPX-V9360	18	76	83	80	51	50	51
	34	79	87	83	53	62	57
	67	81	86	84	58	66	62
CGA-136872	34	45	45	45	50	58	54
	67	55	59	57	46	45	46
Untreated check		0	0	0	0	0	0
LSD		13	11	8	11	18	9
Pr > F		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Stalks at least 1.7 m in height by mid-August were considered large enough to be gathered and piled by the mechanical harvester. With the exception of asulam and the untreated check, all treatments significantly reduced stalk heights below 1.7 m height with height reductions for DPX-V9360 being the most severe (Table 2). Sugarcane stalk numbers for the asulam treatment were comparable with the untreated check. Stalk numbers, however, were significantly reduced, as much as 98 and 81% compared with the untreated check for DPX-V9360 and CGA-136872, respectively. Even though DPX-V9360 reduced both sugarcane plant height and stalk population, itchgrass density was low, indicating its efficacy at 67 g/ha.

In the postemergence-directed studies, visual itchgrass control was similar and averaged 84 and 89% for DPX-V9360 at 34 g/ha and paraquat at 560 g/ha, respectively (Table 3). Itchgrass control with paraquat was greater than that of asulam and ametryn. Sugarcane injury following treatment with DPX-V9360 (stunting) and paraquat (foliar necrosis) was significant and averaged 46 and 22%, respectively.

Compared with the untreated check, herbicide treatments significantly reduced the number of two-node itchgrass stems at Thibodaux (Table 4). Although not significant at Maringouin (p = 0.16), paraquat provided the lowest itchgrass stem counts. When averaged across locations, herbicide treatments significantly reduced the number of two-node itchgrass stems an average of 68% compared with the untreated check. When averaged across locations, only DPX-V9360 significantly reduced sugarcane stalk height and stalk numbers when compared with the other treatments. Significant differences among treatments for stalk height or number were not noted at Thibodaux.

Sucrose content was similar for all treatments (Table 5). Averaged across locations, DPX-V9360 reduced cane yield 61% and sugar yield 63% compared with the untreated check. The non-significance among treatments for cane and sugar yields at Thibodaux (p = 0.28 and p = 0.26, respectively) was a direct reflection of the similarity in stalk number/ha.

Table 2. Itchgrass density and sugarcane stalk height and number as influenced by over-the-top herbicide application at Maringouin and Thibodaux, LA, 1989.

		Itchgrass density (stems/m) band			Sugarcane stalk					
					Height			Number		
Herbicide	Rate	Marin-gouin	Thibo-daux	Avg	Marin-gouin	Thibo-daux	Avg	Marin-gouin	Thibo-daux	Avg
	(g/ha)	(no.)			(m.)			(no./ha x 10^3)		
Asulam	3700	23	47	36	1.9	1.9	1.9	70.1	38.8	54.5
DPX-V9360	18	0	44	22	0.9	1.3	1.1	0.9	9.0	4.9
	34	0	38	19	0.6	1.3	1.0	0.0	4.4	2.2
	67	0	27	14	0.5	1.0	0.8	0.0	2.7	1.4
CGA-136872	34	76	141	109	1.3	1.6	1.5	5.4	15.9	10.7
	67	46	138	92	1.2	1.6	1.4	6.1	16.4	11.3
Untreated check		31	70	51	2.0	2.1	2.1	73.9	39.1	56.5
LSD		31	57	33	0.2	0.2	0.1	21.7	27.9	21.3
Pr > F		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01

Table 3. Visual itchgrass control and sugarcane injury as influenced by postemergence-directed herbicide application at Maringouin and Thibodaux, LA, 1989.

		Itchgrass control			Sugarcane injury		
Herbicide	Rate	Maringouin	Thibodaux	Average	Maringouin	Thibodaux	Average
	(g/ha)	(%)			(%)		
Asulam	3700	83	75	79	0	10	5
DPX-V9360	34	89	79	84	45	48	46
Paraquat	560	93	84	89	16	28	22
Ametryn	2700	73	79	76	8	11	10
Untreated check		0	0	0	0	0	0
LSD (0.05)		5	9	5	7	9	6
Pr > F		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 4. Itchgrass density and sugarcane stalk height and number as influenced by postemergence-directed herbicide application at Maringouin and Thibodaux, LA, 1989.

		Itchgrass density (stems/m) band			Sugarcane stalk					
					Height			Number		
Herbicide	Rate	Maringouin	Thibodaux	Avg	Maringouin	Thibodaux	Avg	Maringouin	Thibodaux	Avg
	(g/ha)	-----------(no.)----------			--------------(m.)-------------			-------(no./ha x 10^3)--------		
Asulam	3700	15	10	13	1.8	1.8	1.8	52.1	41.3	46.7
DPX-V9360	34	10	11	10	1.5	1.6	1.5	16.3	20.1	18.2
Paraquat	560	5	16	11	1.8	1.8	1.8	47.0	40.1	43.6
Ametryn	2700	17	22	20	1.8	1.9	1.9	50.6	49.2	49.9
Untreated check		27	56	42	1.9	1.7	1.8	54.8	28.9	41.9
LSD (0.05)		NS	26	18	0.2	NS	0.2	9.1	NS	13.2
Pr > F		0.16	0.01	0.01	<0.01	0.47	0.02	<0.01	0.28	<0.01

Table 5. Sucrose content of crushed juice and cane and sugar yield as influenced by postemergence-directed herbicide application at Maringouin and Thibodaux, LA, 1989.

		Sucrose			Cane yield			Sugar yield		
Herbicide	Rate	Maringouin	Thibodaux	Avg	Maringouin	Thibodaux	Avg	Maringouin	Thibodaux	Avg
	(g/ha)	-------------(%)-------------			----------(mt/ha)-----------			-------(kg/ha x 10^2)---------		
Asulam	3700	17.3	20.3	18.8	48.1	30.4	39.3	61.4	46.3	53.9
DPX-V9360	34	16.7	18.9	17.8	11.8	13.3	12.6	15.0	18.1	16.6
Paraquat	560	18.1	18.6	18.3	40.3	28.2	34.3	53.6	39.6	46.6
Ametryn	2700	17.9	19.3	18.6	42.4	43.9	43.2	56.1	59.3	57.7
Untreated check		18.4	19.5	19.0	44.9	19.0	32.0	61.6	27.7	44.4
LSD (0.05)		NS	NS	NS	8.5	NS	12.9	12.9	NS	19.7
Pr > F		0.42	0.24	0.49	<0.01	0.28	<0.01	<0.01	0.26	<0.01

CONCLUSIONS

DPX-V9360 provided itchgrass control comparable to asulam and greater than CGA-136872. Injury to sugarcane with DPX-V9360, however, was significant regardless of whether applied over-the-top or postemergence-directed. Although cane tolerance to DPX-V9360 was low, itchgrass control obtained in this study may be applicable in fallowed sugarcane fields. Despite the early injury, paraquat and ametryn applied postemergence-directed provided itchgrass control without reducing sugarcane yields. Asulam provided good to excellent control of itchgrass plants 15 to 30 cm tall with minimal sugarcane injury. Additionally, when asulam and paraquat were applied postemergence-directed, reductions in the number of itchgrass plants/m of row were similar. Paraquat is a cost-effective treatment that is promising but will require precise management to avoid sugarcane injury.

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OCCURENCE OF SUGARCANE BACILLIFORM VIRUS IN A FLORIDA VARIETY COLLECTION

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ABSTRACT

Four hundred thirty-one sugarcane varieties maintained in a germplasm collection by the United States Sugar Corporation were assayed by ELISA, and in a limited number of samples, by electron microscopy for the presence of sugarcane bacilliform virus (SCBV). All of the current commercial varieties, many of the older Florida commercial varieties, varieties of significance in the two Florida breeding programs, varieties of historical importance, and a collection of recently introduced foreign varieties were assayed. SCBV was detected by one or both methods in four noble varieties (*Saccharum officinarum* L.) and 20 interspecific hybrids of *Saccharum* sp. including two varieties from Canal Point (USDA-ARS), four early Florida varieties (Univ. of Fl.), one Hawaiian variety, and 13 foreign varieties. All of the infected Florida varieties were early generation varieties from the 1930-40's. None of the current commercial varieties were infected. In addition to the variety survey, six varieties were sampled at monthly intervals for nine months to determine the seasonal variability in virus titer as determined by ELISA. Over all varieties, the virus titer was highest in July and August and then declined to barely detectable levels by late November. The decline in virus titer appeared to be temperature related. This information will be valuable in future studies to detect SCBV.

INTRODUCTION

In 1988, a virus serologically related to banana streak virus (BSV) was reported for the first time in sugarcane in variety Mex 57-473 from Morocco (Lockhart and Autrey 1988). At that time, the virus was tentatively named sugarcane bacilliform virus (SCBV). Shortly after the first report of SCBV in Morocco, the virus also was found in samples from Hawaii (Lockhart and Autrey 1988), Florida (Comstock and Lockhart 1990, Irey unpublished 1988) and Texas (Comstock and Lockhart 1990). In samples from the USDA germplasm collection, SCBV was detected in 94% of the Noble clones (*Saccharum officinarum* L.) tested. Other than its occurrence in several countries, little is known regarding the effect of SCBV on production, its distribution throughout the world, or the susceptibility of commercial sugarcane clones (interspecific *Saccharum* hybrids). There are indications, however, that SCBV may cause production losses in susceptible varieties (Lockhart and Autrey 1988) and that SCBV may interact synergistically in plants co-infected with sugarcane mosaic virus (Autrey, et al. 1989).

The purpose of this study was to gather some basic information on SCBV distribution and infection characteristics in order to begin to assess the potential impact of SCBV to the Florida industry.

MATERIALS AND METHODS

SAMPLING FOR SCBV

To determine the optimum location within the plant to detect SCBV, leaf samples from various locations on infected plants were collected and assayed by enzyme-linked immunosorbent assay (ELISA) during the month of May, 1990. Leaves were collected fresh in the morning and immediately processed for ELISA. Samples were collected from the whorl, the top visible dewlap leaf (TVD), and the leaf under the TVD (TVD-1). Each leaf sample was further divided into thirds (proximal, middle, and distal) and assayed separately. Samples were collected from 12 plants of three varieties.

To determine the temporal variability in virus titer, samples were collected at monthly intervals from two locations on three plants each of clones D74, La Purple, Badilla, POJ2725, and Akoki 22 and from two plants of Rose Bamboo. Samples were collected for nine months beginning in May, 1990 and ending in January, 1991. The same individual plants were sampled at each sample date; samples were assayed from the distal portion of the whorl leaves and the proximal portion of the TVD leaf on each plant.

ELISA

Assays were performed by the double-antibody sandwich method (Clark and Adams 1977) using antisera prepared against BSV. Immulon II microtiter plates (Dynatech Laboratories, Alexandria, VA) were coated with 2 ug/ml of purified IgG for 4-6 hr at 30 C. Antigen preparations were prepared by grinding leaves minus the midrib at a ratio of 1:5 (w/v) in phosphate buffered saline, pH 7.4, + 0.5% Tween 20, + 2% polyvinylpyrrolidone (PVP, 40000 mw). After being loaded into the coated plates, antigen preparations were incubated overnight at 4 C. Alkaline-phosphatase antibody conjugates in phosphate buffered saline + 0.5% Tween 20 + 0.1% bovine serum albumin were incubated 4 hr at 30 C. After the plates were rinsed, substrate solution (p-nitrophenylphosphate 0.6 mg/ml in 10% diethanolamine, pH 9.8) was added and incubated 60 min at 25 C. The optical density at 405 nm (OD_{405}) was measured on a Biotek EIA reader, model EL-309 (Biotek Instruments, Burlington, VT). A test was considered positive if ELISA readings for the sample exceeded the greater of three times the value of the healthy control or an OD_{405} value greater than 0.050. Tests were repeated for samples with questionable ELISA results. For some samples with repeated weak or questionable ELISA results, SCBV was partially purified and then re-assayed by ELISA. Leaf tissue, minus the midrib, was homogenized in 2.5 volumes (w/v) of 0.1 M Tris-HCl buffer, pH 7.4, containing 2% PVP, 0.5% $NaSO_3$, and 0.2% diethyldithiocarbamic acid. The homogenate was centrifuged for 10 min at 12,000 g and the pellet was discarded. To the supernatant, Triton X-100 was added to 0.5% (v/v) and the mixture centrifuged for 3 hr at 40,000 g at 4 C. The pellet was resuspended in 0.25 ml of Tris-HCl and clarified by mixing with an equal volume of $CHCl_3$ followed by centrifugation in a microfuge for 10 min. Samples were taken from the aqueous layer and tested by ELISA.

Survey

Samples were collected from varieties in two variety collections maintained by the United States Sugar Corporation. Samples were collected from the distal portion of the whorl leaves from a single plant per variety. All samples were assayed by ELISA; samples giving weak or questionable ELISA readings were either re-assayed, partially purified and re-assayed by ELISA, or subjected to electron microscopic examination (Lockhart 1986). In most cases, positive ELISA readings using crude extracts also were verified by electron microscopic evaluation or by partial purification followed by ELISA. Samples were collected from May to August, 1990.

RESULTS

Sampling for SCBV

The highest virus titer, as measured by ELISA, was found in the distal and middle portions of the whorl leaves (Figure 1). In the TVD and TVD-1 leaf positions, the basal portion of the leaf had the highest virus titer, but the OD_{405} readings were almost always lower than the OD_{405} readings from the distal portion of the whorl leaves from the same plant. The highest ELISA readings were obtained during July and August from the distal portion of whorl leaves (Figure 2). Although the virus titer varied between varieties, the general trend was the same for all varieties, in that the virus titer was highest during the warmer months (May - October) and declined to barely detectable levels during the cooler months (November - January).

FIGURE 1. EFFECT OF LEAF POSITION ON ELISA VALUES

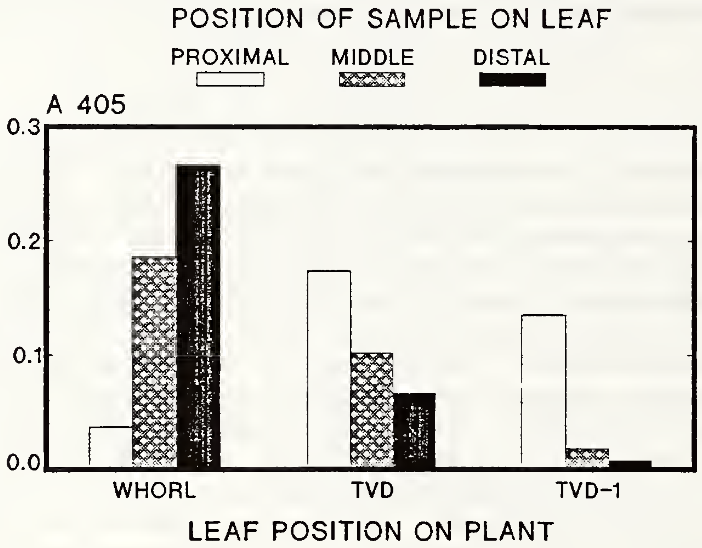

Figure 1. ELISA values from samples collected from the distal, middle, and proximal positions of leaves from the whorl, the top visible dewlap (TVD), and the leaf under the top visible dewlap (TVD-1).

ELISA

Double-antibody sandwich ELISA assays using BSV antiserum were able to reliably detect SCBV in crude extracts under the conditions described; however, OD_{405} readings were low for infected plants of most varieties. During August, OD_{405} values for all samples in the temporal study (distal portion of the whorl leaves) ranged from 0.086 to 1.171 with a mean of 0.345 compared with healthy control readings of -0.013 to 0.009 with a mean of -0.002. Partially purified preparations of SCBV gave OD_{405} readings approximately six times (mean = 0.442) those of readings from crude extracts (mean = .072). There was complete agreement between the results of the ELISA tests and the electron microscopic evaluations for the limited number of samples tested by both methods.

FIGURE 2. ELISA VALUES OVER A 9 MONTH PERIOD

(MEAN OF 6 VARIETIES, 3 PLANTS/VARIETY)

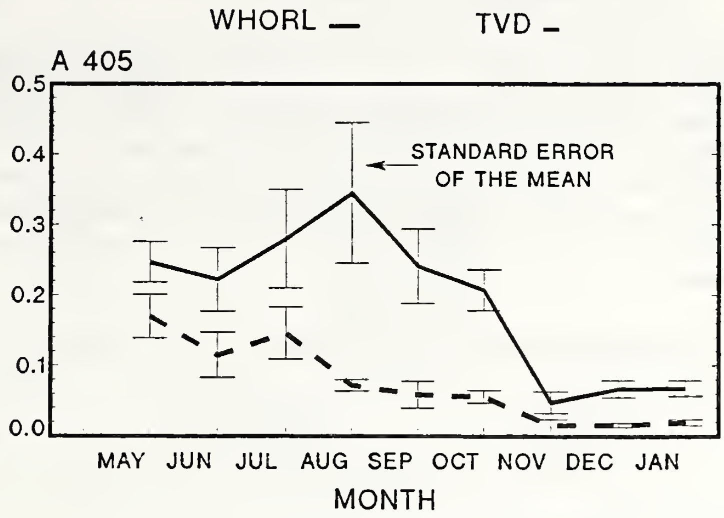

Figure 2. Mean ELISA values of samples collected from six varieties over a nine month period. Samples were collected from the distal portion of whorl leaves and the proximal portion of the top visible dewlap leaves (TVD).

Survey

A total of 431 varieties were tested for SCBV infection (Table 1). Varieties from over 20 breeding programs and countries were represented. Of these, 24 varieties were infected with SCBV as determined by ELISA and electron microscopic evaluation. SCBV infection was found in varieties from Cuba, the Dominican Republic, Hawaii, Java, Reunion, Australia, and Florida as well as in all the noble varieties tested. Of the 323 varieties originating from the current Florida breeding programs (CL and CP varieties), only two early generation CP varieties were infected. Four early generation varieties originating from an early Florida breeding program also were infected. None of the current commercial varieties were infected.

DISCUSSION

ELISA testing using antiserum prepared against BSV detected SCBV in crude plant extracts, but because virus titer was generally low and varied both within the plant and over time, use of the proper sampling protocol was important to reliably detect SCBV. The best sampling protocol was to collect samples from the middle to the distal portion of the whorl leaves during the warmest months (July or August). ELISA data from plants grown in the greenhouse also supported the conclusion that the virus titer was higher under high temperature conditions (data not shown).

Data from the survey suggested that the newer commercial varieties are probably resistant to infection. This conclusion is drawn from several observations. First, many of the infected varieties (Noble varieties, F varieties, and early CP varieties) have been in the USSC collection for a great number of years. Thus, inoculum has probably been available for an extended period of time, yet only a few early generation varieties were infected. It is also possible, however, that the virus was introduced only recently or that if present for many years, that spread did not occur due to the lack of the appropriate vector. The second observation leading to the conclusion that the newer varieties are probably resistant has to do with the heritage of the varieties involved. When pedigrees for the varieties were examined (Tai and Miller 1981, Tew 1987, D. G. Holder unpublished 1991, R. Perdomo personal communication 1991), all of the infected varieties for which pedigrees were available were three generations or less away from the susceptible Noble varieties (Table 2). By comparison, the newer commercial Florida varieties are five or more generations removed from susceptible Noble parentage. Thus, it appears that varieties closely related to Noble varieties are more likely to be susceptible to SCBV infection than the current commercial varieties in the Florida industry.

Although it is likely that the current commercial varieties are resistant to SCBV, virtually no production data is available to assess the impact of this disease. Similarly, no data is published describing resistance levels of commercial varieties in inoculated tests or under high levels of natural infection. Although transmission by mealybugs has been accomplished from sugarcane to banana (Lockhart unpublished), little is known about how the disease is spread in sugarcane. Given the general lack of knowledge of SCBV and its effects on sugarcane, additional work is needed to determine if SCBV is of economic importance. The data presented here provide a starting point for additional research.

Table 1. Origin of naturally infected varieties in two USSC variety collections.

Variety designation	Country of origin	Number of varieties tested	Number of varieties infected[1]
B	Barbados	20	0
C	Cuba	2	1
CL	USA; Clewiston, FL	243	0
CP	USA; Canal Point, FL	80	2
CR	Dominican Republic	9	4
DB	Guyana	3	2
F	USA; Belle Glade, FL	5	4
F	Taiwan	2	0
H	Hawaii	14	1
L	Louisiana	4	0
LCP	Louisiana	2	0
M	Mauritius	5	0
NA	Argentina	2	0
NG	New Guinea	3	0
Noble		4	4
PHIL	Phillipines	2	0
POJ	Java	2	2
PR	Puerto Rico	3	0
Q	Australia	3	1
R	Reunion	2	2
SP	Brazil	15	0
TUC	Argentina	11	0
Misc.	Various	13	1
	Total	431	24

[1] Determined by ELISA or electron microscopic evaluation.

Table 2. Pedigree comparison of SCBV-infected varieties and SCBV-free commercial varieties.

SCBV Infected Varieties		Current Commercial Varieties	
Variety	Generations Away From Noble Cane	Variety	Generations Away From Noble Cane
Badilla	Noble	CP70-1133	5
D-74	Noble	CP72-1210	5
Falsa Crystalina	Noble	CP72-2086	6
La Purple	Noble	CL59-1052	5
C279	1	CL61-620	5
CP31-588	2	CL73-239	5
CP47-193	3		
CR65-185	2		
CR67-400	3		
CR68-25	3		
CR72-34	3		
DB420/60	-[1]		
DB596/61	-		
F31-407	2		
F31-436	2		
F31-762	3		
F36-819	2		
H32-8560	2		
POJ2725	1		
POJ3016	2		
PPQKSTR	2		
Q69	3		
R397	-		
R567	-		

[1] Pedigree not available

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SURVEY AND ESTIMATED INJURY OF THE MEXICAN RICE BORER IN TEXAS SUGARCANE

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ABSTRACT

The Mexican rice borer, *Eoreuma loftini* (Dyar), is the most serious insect pest of sugarcane in Texas. The objectives of this study were to geographically document *E. loftini* injury across the Lower Rio Grande Valley (LRGV), determine within-field distribution of injury, and determine the frequency distribution of injury on stalks with respect to internode position. Injury by *E. loftini* was surveyed in 20 fields during 1989, 20 fields during spring 1990 and 43 fields during fall 1990. Samples (25 plants or stalks) were taken in four locations within each field. Samples taken in the fall suggested a trend for higher injury to stalks in western LRGV fields than eastern. There were no significant differences in samples taken within fields. No significant differences in injury were found between stalks of 'NCo 310' vs. 'CP 70-321' in 1989, but 'NCo 310' stalks contained more injury than 'CP 70-321' stalks in 1990. The overall percentage of bored internodes during 1989 and 1990 averaged 19 and 20.9%, respectively. Results showed more statistical variation among fields than among locations within fields. This variation may be explained by grower management practices (insecticide sprays, irrigation, fertilizer, etc.), salinity problems, or proximity of fields to other gramineous crops infested by *E. loftini*. Basal (lower) internodes were injured more frequently than distal (upper) internodes in both cultivars in 1990.

INTRODUCTION

The Mexican rice borer, *Eoreuma loftini* (Dyar) (Lepidoptera: Pyralidae) was first reported in the Lower Rio Grande Valley (LRGV) in 1980 (8), although it was intercepted regularly at ports of entry on sugarcane, corn, sorghum, and wild grasses during the early 1970's (6). This pest has since replaced *Diatraea saccharalis* (F.) as the primary stalkborer pest in Texas sugarcane. Research during the 1980's centered on life history and biology (17,18), chemical (7, 10, 11, 13) and biological control (1, 2, 5, 16), and host plant resistance (9, 14). However, no information was available on the intensity or location (spatial as well as within-plant) of *E. loftini* injury. The objectives of this study were to geographically document *E. loftini* injury across the LRGV, determine within-field distribution of injury, and determine the frequency distribution of injury on stalks with respect to internode position.

MATERIALS AND METHODS

Twenty sugarcane fields (12 'NCo 310', 8 'CP 70-321') throughout eastern (Cameron Co.) and western (Hidalgo Co.) sections of the LRGV were sampled during October and November, 1989. Within each field, 25 stalks were collected randomly from each corner (northeast, northwest, southeast, southwest). Samples were taken at least 25 rows by 30 m inside the field for each corner. Stalks were split mechanically (Intercane Systems, Windsor, Canada) and the percentage of bored internodes was calculated. In 1990, 20 fields (12 'NCo 310', 8 'CP 70-321') were sampled during April and June, and 43 fields (21 'NCo 310', 22 'CP 70-321') were sampled during October and

November. Spring sampling involved collecting 25 plants from each corner and searching leafsheaths for stalkborer larvae. Within-field sampling during the fall was the same as in 1989 except stalk injury was recorded by internode position. Only the first 14 internodes (basal or lower internode = 1, distal or upper internode = 14) were included in the frequency distribution analysis, although all internodes were included for total injury calculations. Bored internode percentages were subjected to square root transformation before t-test analysis (comparison of 2 variables, Proc T-Test, 15) or analysis of variance (comparison of more than 2 variables, Proc GLM, 15). Means were separated using the Ryan-Elinot-Gabriel-Welsch multiple range test (REGWQ, 15).

RESULTS

Stalk injury in 1989 averaged 19% bored internodes, with a range of 3.7 to 41.3% bored internodes (Table 1). Four of 20 fields had greater than 30% bored internodes. There was higher stalk injury in western than eastern fields [23.8% ± 10.6 (SD) vs. 14.1% ± 11.2, respectively, n=10, *P*= 0.032]. Within-field distribution of *E. loftini* injury showed no statistical differences among the four corners (*P* = 0.17). Comparison between cultivars showed numerically but not statistically higher injury to NCo 310 than CP 70-321 fields (20.5% ± 13.1, n=12; 16.7% ± 9.7, n=8, respectively; *P*=0.559).

Table 1. Comparison of percent *Eoreuma loftini*-bored internodes among fields and LRGV locations for cultivars NCo 310 and CP 70-321, fall 1989.

Field	Location	% bored Internodes Mean (SD)	Field	Location	% bored Internodes Mean (SD)
-------------NCo 310------------			-----------CP 70-321------------		
1	east	7.4 (5.2)	13	east	20.7 (10.7)
2	east	24.1 (12.2)	14	east	5.1 (3.6)
3	east	39.1 (8.9)	15	east	12.2 (8.6)
4	east	4.9 (2.4)	16	east	15.4 (5.9)
5	east	3.7 (3.6)	17	east	8.8 (4.2)
6	west	41.3 (3.0)	18	west	36.9 (20.6)
7	west	14.3 (3.1)	19	west	13.9 (2.6)
8	west	37.0 (19.3)	20	west	20.3 (9.5)
9	west	20.9 (5.8)			
10	west	12.3 (3.2)			
11	west	21.7 (10.0)			
12	west	19.3 (9.2)			

Early season infested-plant samples in April 1990 showed no statistical differences among LRGV locations (west 15.0% ± 10.5, east 13.4% ± 4.7, n=10, *P*=0.961), within field corners (*P* = 0.654), or cultivars (NCo 310 14.9% ± 8.9, n=13; CP 70-321 12.9% ± 6.2, n=7; *P*=0.741). Infested-plant samples taken in June did not show statistical differences among locations (west 10.9% ± 8.5, east 7.5% ± 4.0, n=10, *P*=0.464), within field corners (*P* = 0.063), or cultivars (CP 70-321 9.4% ± 5.5, n=9; NCo 310 9.0% ± 7.7, n=11; *P*= 0.838).

Stalk injury in fall 1990 samples averaged 20.9% bored internodes, with a range of 8.6 to 48.7% (Table 2). There was a trend for higher injury in western compared to eastern fields (23.4% ± 10.2, n=21 vs. 18.4% ± 8.5, n=22, respectively, *P*= 0.055). There were no statistical differences among within-field corners (*P* = 0.763). 'NCo 310' stalks exhibited higher injury than 'CP 70-321' stalks (23.5% ± 9.6, n=21; 18.3% ± 9.1, n=22, respectively; *P*=0.046). Frequency distribution of internode injury for both cultivars suggested more injury to middle and lower internodes than to upper internodes (Fig. 1).

Table 2. Comparison of percent *Eoreuma loftini* bored internodes among fields and LRGV locations for cultivars NCo 310 and CP 70-321, fall 1990.

Field	Location	% bored Internodes Mean (SD)	Field	Location	% bored Internodes Mean (SD)
-------------NCo 310------------			-----------CP 70-321------------		
1	east	16.9 (7.2)	22	east	12.9 (6.1)
2	east	25.6 (13.0)	23	east	17.0 (6.2)
3	east	19.8 (7.4)	24	east	40.8 (27.0)
4	east	15.6 (3.4)	25	east	11.2 (6.5)
5	east	23.5 (5.7)	26	east	11.4 (5.6)
6	east	22.0 (7.4)	27	east	11.9 (2.6)
7	east	14.3 (6.3)	28	east	10.6 (5.0)
8	east	26.7 (13.1)	29	east	15.1 (7.6)
9	east	34.5 (9.8)	30	east	8.6 (1.0)
10	east	25.8 (8.1)	31	east	20.5 (4.7)
11	west	21.3 (4.1)	32	east	9.4 (3.9)
12	west	41.5 (8.1)	33	east	10.3 (8.2)
13	west	17.2 (10.1)	34	west	18.9 (4.6)
14	west	8.6 (2.2)	35	west	15.9 (6.5)
15	west	26.9 (10.9)	36	west	23.1 (11.2)
16	west	11.2 (1.5)	37	west	21.3 (2.4)
17	west	48.7 (5.0)	38	west	13.1 (3.8)
18	west	15.3 (5.2)	39	west	14.4 (6.0)
19	west	27.8 (9.2)	40	west	22.0 (8.6)
20	west	23.3 (4.9)	41	west	35.5 (13.1)
21	west	27.4 (4.5)	42	west	36.3 (8.5)
			43	west	22.5 (8.8)

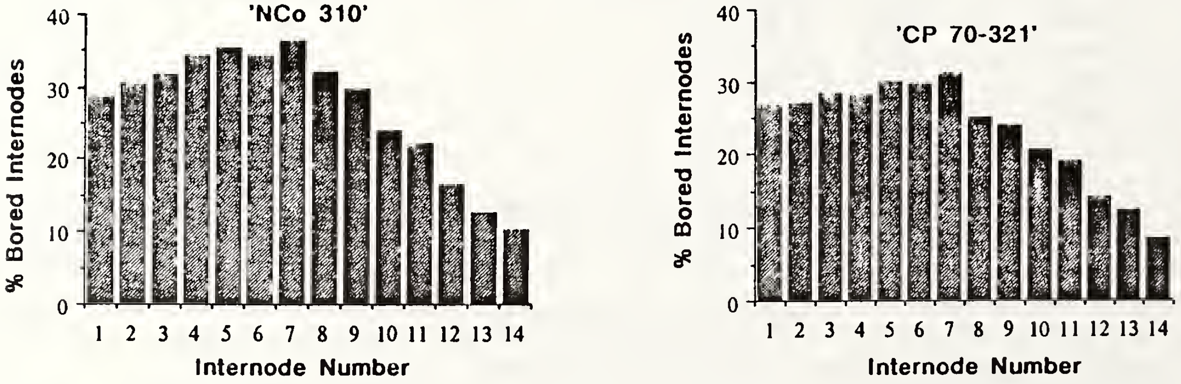

Fig. 1. Frequency distribution of *Eoreuma loftini* injured internodes (basal or lower internode = 1, distal or upper internode = 14) for 'NCo 310' and 'CP 70-321' stalks, fall 1990, LRGV, Texas.

DISCUSSION

Numerical trends in both years were for higher stalk injury in western LRGV fields and in 'NCo 310' fields. Analyses suggest that there is more variation among fields than among locations (corners) within fields. This high among-field variation is exemplified by the large ranges in injury to the same cultivar (1989, NCo 310: 3.7 - 41.3%, CP 70-321: 5.1 - 36.9%; 1990, NCo 310: 8.6 - 48.7%, CP 70-321: 8.6 - 40.8%). This variation may be explained by grower management practices (insecticide sprays, irrigation, fertilizer, etc.), salinity problems, or proximity of fields to other gramineous crops infested by *E. loftini*.

Injury by *D. saccharalis* in Texas sugarcane prior to the successful 1977 establishment of the braconid parasitoid *Cotesia* [=*Apanteles*] *flavipes* (Cameron) (4) averaged 18.7% bored internodes in untreated plots in 1972 (3) and about 31% (12-51%) in 1977 (12). Thus, sugarcane injury by stalkborers appears to have remained approximately the same, with the range of bored internodes (3.7 - 48.7%) similar to that observed in the mid 1970's. Direct yield reduction per internode bored by *E. loftini* has not been determined for any cultivar, therefore effects of equivalent percentages of bored internodes by the two species cannot be directly compared. Mexican rice borer injury appears to be located in older internodes which usually contain higher amounts of sugar. Therefore future areas of research should include studies designed to determine the economic damage potential of this pest, and the variability of *E. loftini* infestation and injury among cultivars and among internodes within stalks.

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SUGARCANE EMERGENCE FROM PLANT AND RATOON SOURCES OF SEED CANE

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ABSTRACT

Growers of sugarcane (a complex interspecific hybrid of *Saccharum* spp.) in Florida obtain seed cane primarily from plant-cane rather than ratoon crops. Growers would benefit by using ratoon seed cane if doing so would not reduce yields. Using ratoon seed cane could ease logistical restraints and enhance the use of disease-free seed cane. The main objective of this study was to compare emergence levels from seed cane of different cultivars and crops, ranging from the plant-cane crop through the second-ratoon crop. Four greenhouse studies were conducted from 1985 through 1987. Plant-cane seed cane was obtained from fields that had been planted in the previous December or January. Ratoon seed cane was obtained from fields that had been harvested the previous March. In two of the four experiments, there were no differences in emergence due to crop of seed cane. In the other two experiments, first-ratoon seed cane had the highest level of emergence. Ratoon seed cane of cultivar CP 72-2086 ranked low in emergence in all three experiments in which it was tested. Cultivars CP 72-1210 and CP 73-1547 often showed high emergence levels from first-ratoon seed cane. If these greenhouse results transfer to commercial conditions, sugarcane growers in Florida could use first- or second-ratoon seed cane and expect emergence at least equal to that of plant-cane seed cane for all cultivars tested except CP 72-2086.

INTRODUCTION

Plant cane through second-ratoon cane comprises more than 82% of Florida's sugarcane acreage. Plant cane and first-ratoon cane each constitute about 30% and second-ratoon cane makes up about 22% of the total cane acreage (Coale and Glaz, 1991). No published survey reveals which crops are used most extensively as seed cane for planting commercial fields. Probably most sugarcane growers in Florida use seed cane from the plant-cane crop because they expect that doing so will result in better emergence and higher yields in their newly planted fields.

If seed cane from ratoon fields could produce yields at least equal to those of seed cane from plant-cane fields, it would be to the growers' advantage to use seed cane from ratoon as well as plant-cane fields. At times, growers choose a seed-cane source because it is the closest plant-cane field to the field they are planting. By also using ratoon seed cane, growers would reduce transportation distances of seed cane, and would be more likely to find available seed cane of desirable cultivars.

A common practice in Florida is to plant sugarcane successively. In the successive planting system, growers prepare land for planting immediately after harvesting a final-ratoon sugarcane crop (often second ratoon). Time is often a major constraint in successive planting because growers cannot begin successively planting a field until they have harvested it. Thus, preparation of fields to be planted successively cannot begin until late October, when the Florida sugarcane harvest begins. Under the fallow planting system, growers plant sugarcane as early as September. If growers use second-ratoon fields as seed cane to fallow plant, then they could successively plant the fields they had harvested for seed cane. This would allow growers to begin their successive planting earlier.

Also, some growers in Florida control ratoon stunting disease (*Clavibacter xyli* subsp. *xyli* Davis) by planting disease-free seed cane. Doing so would be easier if they used the same disease-free seed cane three times, as plant cane, first ratoon, and second ratoon rather than only as plant cane.

The major objective of this study was to compare emergence levels of seed cane derived from the plant-cane, first-ratoon, and second-ratoon crops of various sugarcane cultivars under greenhouse conditions. This was to serve as a first step in determining effects on yield of crop of seed cane. We also sought to determine if crop of seed cane and cultivar interacted with stalk section and time.

MATERIALS AND METHODS

From September 1985 through March 1987, we conducted four greenhouse experiments at Canal Point, Florida. In each experiment, one 40 x 55 x 9 cm container comprised a full replicate of each treatment. We filled all containers with approximately 8 cm of Torry muck soil (euic, hyperthermic Typic Medisaprist) collected and sterilized at Canal Point. Single-bud cuttings served as seed pieces.

Experiment 1 was planted 16 and 17 Sept. 1985. On 13 Sept. 1985 seed cane was cut and topped as it would be for commercial planting. We counted the number of buds on each stalk and divided them into thirds. We labelled the buds from the bottom third of each stalk as "Bottom," the top third as "Top," and the remaining third as "Middle." Topped stalks typically had from 18 to 24 buds. The 18 to 24 single-bud pieces from one stalk made up one replication of one treatment.

We arranged the cultivar and crop treatments in containers as a factorial in a randomized complete-block design. We arranged stalk section as a split plot within each cultivar x crop treatment (container). Thus, each container comprised a cultivar x crop treatment divided into three sections, top, middle, and bottom. We replicated all treatments four times.

Experiment 1 tested ten sugarcane cultivars (Table 1). For this experiment and Experiment 2, the seed cane sources had been planted in the field as follows: plant-cane seed cane, 19 Dec. 1984; first-ratoon seed cane, 1 Dec. 1983; and second-ratoon seed cane, 10 Nov. 1982. The seed cane from the ratoon crops had been harvested in March 1985. Temperatures dropped to near freezing (33° F) on 22 Jan. 1985.

Emergence percentages of each treatment were counted on 25 Sept., 2 Oct., 10 Oct., and 15 Oct. 1985. In this and all other experiments, we considered that a plant had emerged if it was growing above the soil surface. If a plant had emerged and later died, at the later counting date we did not count it as emerged. The analyses of cultivar, crop, stalk section, and their interactions used only data from the 15 October count (final count). To determine the effects of time on the above three factors, we added counting date as a split-split plot. In this and all later experiments, significant differences were sought at $P = 0.10$ with the LSD. We calculated LSD's and used them for all treatment comparisons regardless of significance of overall F values (Carmer and Walker, 1985).

We planted Experiment 2 on 11 Feb. 1986. Seed cane had been cut 10 Feb. 1986. Most cultural and statistical practices were similar to those of Experiment 1. Two exceptions were that we planted three, not four replications and only five cultivars. The cultivars were CP 65-357, CP 70-1133, CP 72-1210, CP 73-1547, and CP 74-2005. We counted emergence percentages until 35 days after planting, beginning 7 days after planting as follows (all in 1986): 18 February, 21 February, 24 February, 28 February, 3 March, 6 March, 10 March, 14 March, and 17 March.

We planted Experiment 3 on 10 Oct. 1986. Seed cane had been cut on 8 Oct. 1986. We did not plant the bottom two buds from each stalk nor did we plant damaged or germinated buds. We did not separate buds into top, middle, and bottom according to stalk position in this experiment or

Experiment 4. Both experiments were planted as randomized complete blocks with cultivar and crop treatments arranged as factorials with three replications.

Cultivars planted in Experiments 3 and 4 were CP 70-1133, CP 72-1210, CP 72-2086, CP 73-1547, and CP 74-2005. Counting dates for Experiment 3 were 17 October, 24 October, 31 October, and 7 November, all in 1986. For this experiment and Experiment 4, plant-cane seed cane had been planted 3 Jan. 1986, first-ratoon seed cane on 19 Dec, 1984, and second-ratoon seed cane on 1 Dec. 1983. Ratoon seed canes were obtained from fields that had been harvested in March 1986. Temperatures dropped below freezing on 29 Jan. 1986 (30° F). Other procedures for Experiment 3 were similar to those of Experiment 2.

We cut seed cane for Experiment 4 on 5 March 1987 and planted it on 6 March 1987. All procedures except the following were similar to those of Experiment 3. After cutting and topping seed cane according to commercial practices, we discarded the top two buds and planted the next 10 healthy buds from the top of the stalk. We planted buds from two stalks in each container. Counting dates in 1987 were 13 March, 17 March, 23 March, 27 March, 30 March, 3 April, and 6 April.

For each experiment, we regressed the percentage of buds emerged on days after planting (Fig. 1). We combined data from all four experiments to calculate the mean percentage emergence for each crop of seed cane (Fig. 2). Means for percent buds emerged by stalk section came from combined data of the first two experiments (Fig. 3). For parameters calculated from combined experiments, we used pooled variances and t tests to determine significance of treatment differences.

Often with percentage data, the arcsin or square root transformation is applied to the data before performing analyses. According to Steel and Torrie (page 158, 1960), if a range of percentages is between 30 and 70, "it is doubtful if any transformation is needed." Much of our data were close to 30 and 70%, but did not fit neatly into these boundaries. Therefore, we also analyzed the data with arcsin and square root transformations. The results were similar to those obtained without transforming the data. For simplicity, all of the reported analyses were calculated from the original data.

RESULTS AND DISCUSSION

In all experiments, plant-cane seed cane was chronologically older than ratoon seed cane by about 2 months. However, there were cold temperatures and one freeze that slowed the growth of the plant-cane seed cane during these extra two months (January and February). Therefore, we expect that the differences in chronological age between plant-cane and ratoon seed cane had minimal effects on the results.

Experiment 1

The mean emergence percentage of CP 75-1553 was significantly lower than that of any other cultivar except CP 75-1632 in Experiment 1 (Table 1). The mean percentage emergence of CP 72-1210 was significantly higher than that of CP 75-1632. Otherwise, there were no significant differences in mean emergence percentages among cultivars.

Table 1. Final percent emergence after 3 weeks, of buds from seed cane of 10 sugarcane cultivars and 3 crops planted in a greenhous experiment in September, 1985.

	Crop of seed cane			
Cultivar	Plant cane	First ratoon	Second ratoon	Mean[1]
	Buds emerged (%)			
CP 72-1210	72.1	96.7	84.8	84.5
CP 72-2086	94.6	75.9	75.3	81.9
CP 74-2005	71.1	95.3	79.4	81.9
CP 65-357	59.8	96.6	82.4	79.6
CP 70-1527	70.3	76.3	87.3	78.0
CP 70-1133	82.9	71.8	77.7	77.5
CP 73-1547	68.6	97.0	64.2	76.6
CP 75-1082	55.5	72.9	94.9	74.4
CP 75-1632	74.3	71.9	62.9	69.7
CP 75-1553	69.0	57.8	53.9	60.2
Mean[2]	71.8	81.2	76.3	76.4

[1] LSD (P = 0.10) for determining differences among cultivar means is 12.7%.

[2] LSD (P = 0.10) for determining differences among crops of seed cane is 7.0% and for cultivar x crop of seed cane interactions is 22.1%.

Seed cane from the first-ratoon crop had a significantly higher level of emergence than seed cane from the plant-cane crop. The increase in percent emergence of second-ratoon seed cane compared to plant-cane seed cane was substantial but not significant (P = 0.14).

Several significant cultivar x crop of seed cane interactions occurred. The emergence levels from plant-cane seed cane for CP 65-357, CP 72-1210, and CP 75-1082 were low compared to their levels from first- and second-ratoon seed cane. Conversely, CP 72-2086 tended to have higher emergence levels from plant-cane seed cane than from the mean of the two ratoon seed cane treatments (P = 0.16). The same tendency was true to a lesser degree with CP 75-1553. The tendency of the other cultivars was to have the most emergence from first-ratoon seed cane. This was particularly true for CP 73-1547 and CP 74-2005.

The effect of stalk section on emergence was also tested (Table 2). The top portion of the stalk had the highest level of emergence, followed by the middle portion, and then the bottom portion. This tendency held for all crops of seed cane and for all cultivars except CP 65-357 (data not shown). For CP 65-357, emergence from the bottom portion of the stalk was higher than from the middle portion of the stalk. This difference was not significant.

Table 2. Final percent emergence of buds from 3 stalk sections and 3 crops planted in 2 greenhouse experiments.

Stalk section	Experiment	Plant cane	First ratoon	Second ratoon	Mean[1]
		Crop of seed cane			
		Buds emerged (%)			
Bottom	1	61.9	72.8	67.8	67.5
Middle	1	65.5	77.1	75.2	72.6
Top	1	88.0	93.7	85.9	89.2
Mean[2]	1	71.8	81.2	76.3	76.4
Bottom	2	34.7	25.6	14.9	25.0
Middle	2	22.7	55.8	25.1	34.5
Top	2	36.8	81.0	51.6	56.5
Mean[3]	2	31.4	54.1	30.5	38.7

[1] LSD's (P = 0.10) for determining differences among stalk section means are 3.5% in Experiment 1 and 5.6% in Experiment 2.

[2] LSD (P = 0.10) for determining differences among crop x stalk section interactions in Experiment 1 is 6.1%.

[3] LSD (P = 0.10) for determining differences among crop x stalk section interactions in Experiment 2 is 9.7%.

All of the above data refer to the final emergence counts. We also checked emergence at weekly intervals 4 times (Fig. 1). All the variables, cultivar, crop, and stalk section showed significant interactions with time (data not shown). The cause for the significant interaction with cultivars is that some cultivars (CP 65-357, CP 70-1133, CP 74-2005, and CP 75-1632) had more emergence at the first counting date than others. The three crop treatments had similar emergence levels after one week. By the second week, they separated into their final ranking of first ratoon as the highest and plant cane as the lowest. Seed cane from the top portion of the stalk emerged more rapidly than from the middle or bottom portions.

Experiment 2

Experiment 2 evaluated only five cultivars compared to the 10 evaluated in Experiment 1. The overall emergence in Experiment 2 was less than that of Experiment 1, probably because Experiment 2 was planted after a freeze (Table 3). Also, the cane in this experiment was chronologically older (Feb cutting) than the cane of Experiment 1 (Sept cutting).

Table 3. Final percent emergence of buds from seed cane of 5 sugarcane cultivars and 3 crops planted in a greenhouse experiment in February, 1986.

Cultivar	Crop of seed cane Plant cane	First ratoon	Second ratoon	Mean[1]
	Buds emerged (%)			
CP 72-1210	45.8	69.8	24.2	46.6
CP 65-357	37.4	47.7	42.8	42.6
CP 74-2005	30.2	47.7	34.5	37.5
CP 70-1133	26.4	46.1	30.9	34.5
CP 73-1547	17.1	59.4	20.2	32.3
Mean[2]	31.4	54.1	30.5	38.7

[1] LSD (P = 0.10) for determining differences among cultivar means is 8.4%.

[2] LSD (P = 0.10) for determining differences among crops of seed cane is 6.5% and for cultivar x crop of seed cane interactions is 14.5%.

CP 72-1210 had a significantly greater emergence percentage than all the other cultivars except CP 65-357. CP 70-1133, CP 74-2005 and CP 65-357 had similar levels of emergence. CP 73-1547 had significantly lower emergence than CP 65-357. CP 65-357 was also unlike the other cultivars because its emergence of seed cane from all three crops was similar. Except for CP 74-2005, the emergence levels of the other three cultivars were significantly greater with first-ratoon seed cane than with seed cane from the plant-cane or second-ratoon crops. The increase in emergence in first-ratoon seed cane of CP 74-2005 was significantly more than its second-ratoon seed-cane emergence at P = 0.13.

Emergence results from stalk sections were similar to those of Experiment 1. The greatest emergence came from the top stalk portion and the least came from the bottom stalk portion (Table 2). However, seed cane from the plant-cane crop had significantly more emergence from the bottom than from the middle stalk portion in this experiment.

Emergence was monitored for 35 days after planting (Fig. 1). As in Experiment 1, cultivar, crop, and stalk section interacted significantly with time (data not shown). CP 65-357 had the most emergence early, CP 70-1133, CP 73-1547, and CP 74-2005 all had similarly moderate levels of emergence early, and CP 72-1210 had the lowest levels of emergence at the early dates. Seed cane from the first-ratoon crop had the most emergence early and seed cane from the plant-cane and second-ratoon crops gave similar levels of emergence at the early counting dates. As in the first experiment, seed cane from the top stalk portion emerged earlier than did seed cane from the bottom or middle stalk portions.

Experiment 3

CP 72-1210 showed significantly more emergence than all other cultivars except CP 74-2005 in Experiment 3 (Table 4). Its emergence percentage was significantly higher than that of CP 74-2005 at P = 0.11. CP 70-1133, CP 73-1547, CP 74-2005, and CP 72-2086 all had similar levels of emergence. There were no significant differences for overall mean emergence percentages among crops. However, the emergence from first-ratoon seed cane of CP 72-2086 was significantly less than from its plant-cane or second-ratoon seed cane. All other cultivars had similar emergence levels, regardless of seed cane crop.

Table 4. Final percent emergence of buds from seed cane of 5 sugarcane cultivars and 3 crops planted in a greenhouse experiment in October, 1986.

	Crop of seed cane			
Cultivar	Plant cane	First ratoon	Second ratoon	Mean[1]
	Buds emerged (%)			
CP 72-1210	90.8	88.2	92.5	90.5
CP 74-2005	73.3	81.3	85.0	80.0
CP 70-1133	80.0	86.7	71.8	79.5
CP 72-2086	89.2	63.0	84.5	78.9
CP 73-1547	75.0	75.2	66.7	72.3
Mean[2]	81.7	78.9	80.1	80.2

[1] LSD (P = 0.10) for determining differences among cultivar means is 10.9%.

[2] LSD (P = 0.10) for determining differences among crops of seed cane is 8.4% and for determining differences among cultivar x crop of seed cane interactions is 18.8%.

This experiment did not measure the effect of stalk section on emergence due to the consistent results obtained in the first two experiments on this effect. Emergence counts were taken at weekly intervals to determine if some treatments emerged more rapidly than others. The overall rate of emergence from this experiment is shown in Figure 1. As in the previous experiments, cultivar and crop interacted significantly with time (data not shown). CP 70-1133 had higher emergence percentages soon after planting than the other cultivars. CP 73-1547, CP 74-2005, and CP 72-2086 had similarly moderate levels of emergence at the early dates. CP 72-1210 had significantly lower emergence than the other four cultivars in the first of the 2 weeks in which emergence levels were counted. Plant-cane seed cane had significantly more emergence than ratoon seed cane 1 week after planting.

Experiment 4

In Experiment 4, CP 72-1210 once again had a high level of emergence, although it was only significantly higher than that of CP 70-1133 (Table 5). The level of emergence of CP 72-2086 was also significantly higher than that of CP 70-1133. There were no significant differences among crops. The comparison among crops that came closest to significance was that first-ratoon seed cane had more emergence than second-ratoon seed cane at P = 0.23. There were no significant cultivar x crop of seed cane interactions. However, CP 72-2086 once again had low emergence from one of the ratoon seed canes. Its second-ratoon seed cane had less emergence than its plant-cane or first-ratoon seed canes at P = 0.24. Although P = 0.24 is much greater than our stated level of P = 0.10, growers should still exercise caution with ratoon seed cane of CP 72-2086, because this trend was repeated in other experiments reported here.

Table 5. Final percent emergence of buds from seed cane of 5 sugarcane cultivars and 3 crops planted in a greenhouse experiment in March, 1987.

	Crop of seed cane			
Cultivar	Plant cane	First ratoon	Second ratoon	Mean[1]
	Buds emerged(%)			
CP 72-1210	73.3	73.3	70.0	72.2
CP 72-2086	73.3	73.3	60.0	68.9
CP 73-1547	66.7	68.3	68.3	67.8
CP 74-2005	76.7	63.3	61.7	67.2
CP 70-1133	51.7	66.7	55.0	57.8
Mean[2]	68.3	69.0	63.0	66.8

[1] LSD (P = 0.10) for determining differences among cultivar means is 10.8%.

[2] LSD (P = 0.10) for determining differences among crops of seed cane is 8.4% and for cultivar x crop of seed cane interactions is 18.7%.

Seven emergence counts were made during the 31 day period immediately after planting (Fig. 1). Cultivars interacted significantly with time (data not shown). CP 70-1133 and CP 73-1547 emerged quickly, reaching maximum emergence levels by 17 days after planting. CP 72-1210, CP 74-2005, and CP 72-2086 emerged more slowly, not reaching maximum levels until at least 24 days after planting. There were no significant interactions with crop and time.

General Conclusions from all Experiments

Figure 1 shows the best fitting regression curves for emergence rates across all treatments over time in each experiment. In the experiments in which counts were taken only four times, the best fits were linear. In the other two experiments in which seven or nine counts were taken, the best fits were quadratic. Emergence levels were similar in all the experiments except Experiment 2 which was planted after the seed cane had been exposed to a freeze. The two quadratic curves show that counts need to be taken for 25-30 days to assure recording maximum levels of emergence. CP 70-1133 and

CP 65-357 emerged more rapidly than other cultivars. No crop of seed cane treatment consistently had more rapid emergence than the others. Emergence from the top stalk section was more rapid than from the middle or bottom sections.

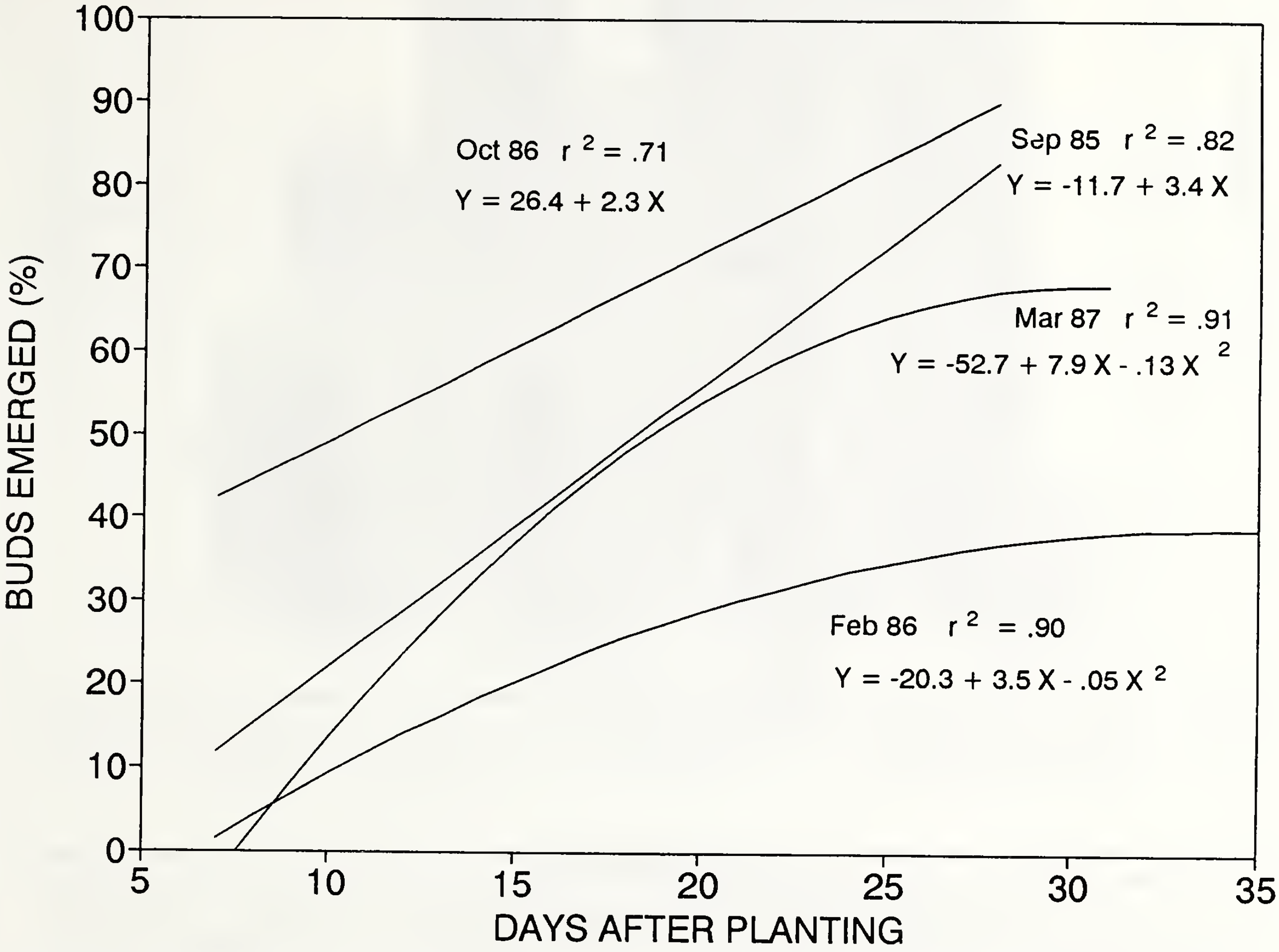

Figure 1. Regressions of percentage of buds emerged on days after planting averaged over cultivars, crop, and stalk section for four experiments. (Stalk section treatment included only in Sept. 85 and Feb. 86 experiments.)

Figure 2 contains the mean emergence percentages for each crop when averaged across cultivars and stalk sections. Overall, there were no significant differences in percent emergence due to crop of seed cane. If these emergence rates hold up under field conditions, there would be no emergence advantage expected from plant-cane seed cane compared to ratoon seed cane. Based on these greenhouse results, growers should expect seed cane of plant-cane through second-ratoon to emerge similarly for most commercial conditions. However, yields from these expected similar emergence levels still should be verified under commercial conditions.

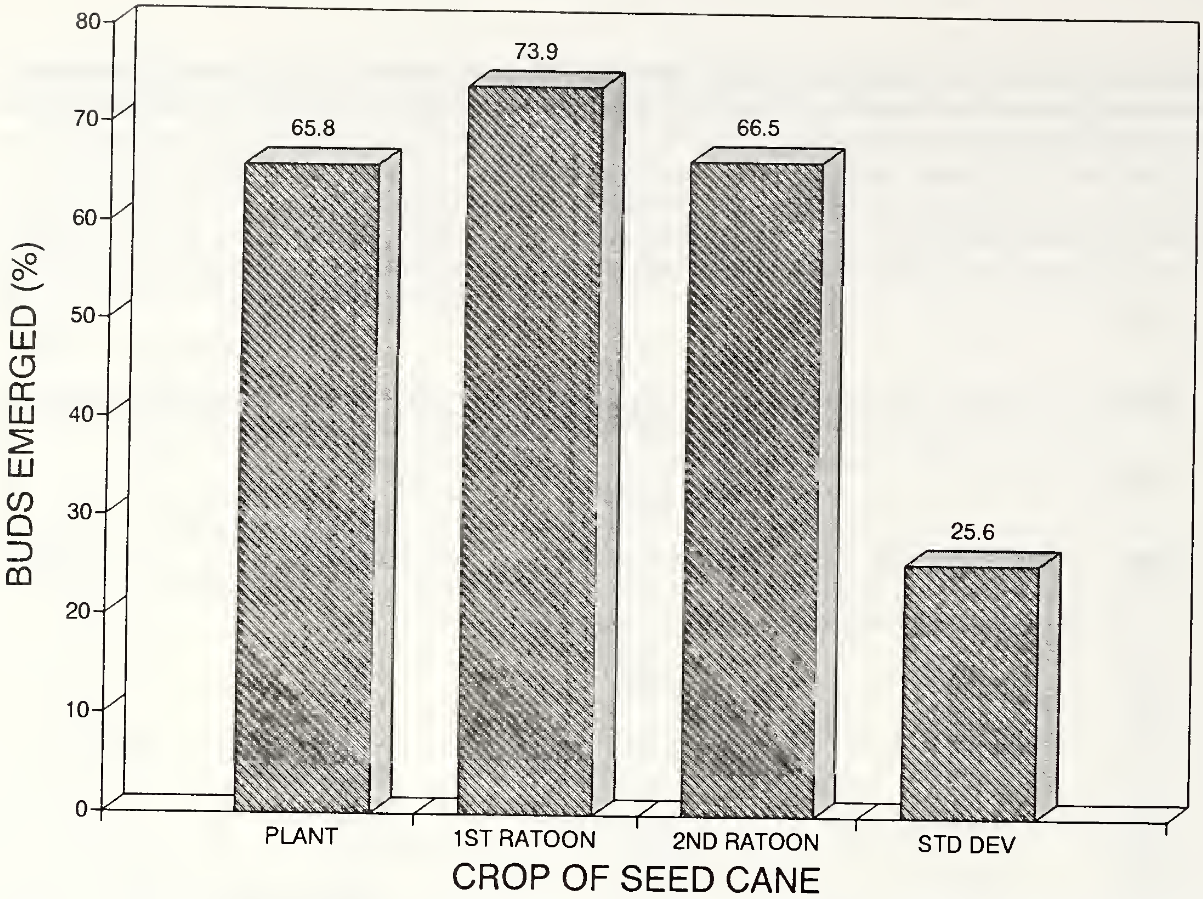

Figure 2. Final mean percentage emergences of three crop treatments averaged over cultivars and stalk sections from four experiments. (Stalk section treatment included only in Sept. 85 and Feb. 86 experiments.)

This study indicates precaution in the use of ratoon seed cane of CP 72-2086. This cultivar was included in three of the four experiments. In all three, a tendency for reduced emergence occurred in at least one of its ratoon seed-cane treatments compared to its plant-cane seed cane. CP 72-2086 is susceptible to pineapple disease caused by the fungus *Ceratocystis paradoxa (Dade) C. Moreau* (Coale, 1989). However, we used sterilized soil in all four experiments, so pineapple disease probably did not affect CP 72-2086 or any other treatment in these experiments.

CP 72-1210 and CP 73-1547 had significantly higher emergence percentages from first-ratoon seed cane than from the other two crops in two of the four experiments. In the other two experiments, their emergence levels from plant-cane and first-ratoon seed canes were similar. To optimize their chances of having good emergence, growers should choose first-ratoon seed cane of these two cultivars. An advantage of CP 72-1210 was its consistently high levels of emergence. Although its emergence was not always significantly higher than the emergence of all other cultivars, it ranked highest in emergence in all four experiments.

Figure 3 shows the means from the first two experiments for emergence levels by stalk section. Seed cane from the top portion of the stalk had significantly more emergence than seed cane from the middle or bottom portions. Two previous studies also found that emergence was highest from the top section of the stalk. However, these studies found that emergence from the bottom stalk section was higher than or equal to emergence from the middle stalk section (Clements, 1940 and Moir, 1922).

Growers attempting to obtain good stands with minimal seed cane should plant two lines of seed cane. Every pair of stalks should lie with the top of one stalk next to the bottom of the other. Farmers in other countries who farm sugarcane labor intensively should obtain all seed cane from top stalk sections.

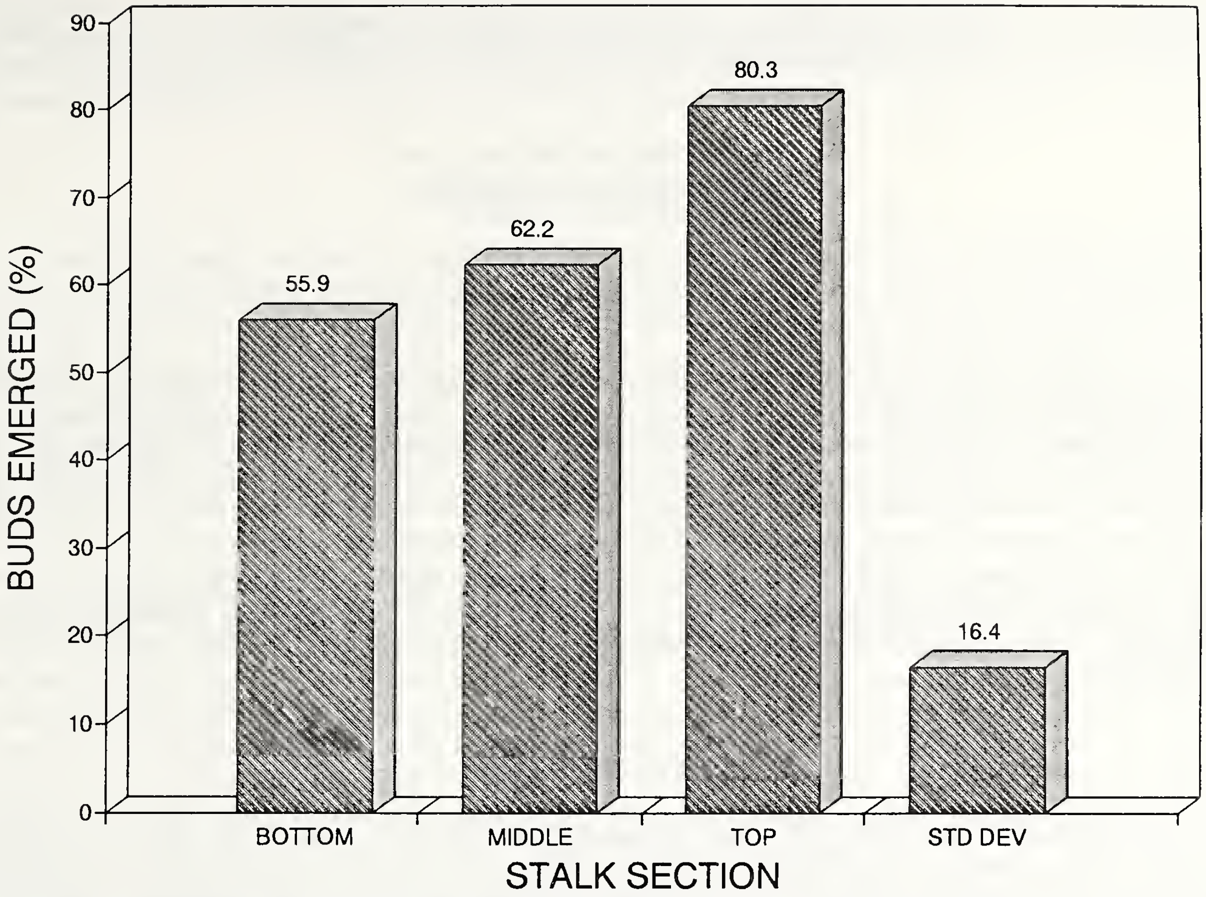

Figure 3. Final mean percentage emergences of three stalk-section treatments averaged over cultivars and crops of seed cane from two experiments.

ACKNOWLEDGMENTS

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POPULATION LEVELS OF PLANT-PARASITIC NEMATODES ASSOCIATED WITH SUGARCANE IN FLORIDA

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ABSTRACT

A survey during 1983-1989 gave insight into population levels of plant-parasitic nematodes associated with commercial sugarcane fields in south Florida. Twelve different genera of nematodes were associated with sugarcane, and a complex of several of these genera was usually present in an individual field. The specific complex varied depending on soil type. Root-knot and stubby-root nematodes were more abundant in sand (>95% silica). Sheath, sheathoid, awl and lance nematodes were only observed in sand. Stunt nematodes were more abundant in muck soil (>45% organic matter). Spiral, ring and lesion nematodes were generally as prevalent in muck as in sand soils. More than 2000 parasitic nematodes (all genera in a complex) per 100 ml soil were sometimes present. Data from the survey form a base to which nematode levels observed in future samples can be compared.

INTRODUCTION

Plant-parasitic nematodes have been recognized in many areas around the world as sometimes being important pests of sugarcane (Birchfield 1984). A complex of several different genera of nematodes together is usually found in sugarcane. Damage by nematodes can result in hidden yield losses since the presence of nematodes as well as their often subtle effect on sugarcane growth may go unnoticed. Visible symptoms of a nematode infestation occasionally occur and may include stunted shoot growth, inhibited leaf production, reductions in the number of stalk internodes, and/or leaf yellowing (Birchfield 1984). The inhibition of growth associated with nematode damage may result in yield losses. Feeding by nematodes creates open wounds through which microorganisms may be introduced, and some of these microorganisms have been associated with diseases of sugarcane roots (Birchfield 1984). Nematodes and fungal pathogens of roots have been linked together as causal agents of a condition in sugarcane in Australia known as the Northern Poor Root Syndrome (Chandler 1984). *Pratylenchus zeae* Graham (Khan 1963) and *Meloidogyne javanica* (Treub) (Khurana and Singh 1971, Valle-Lamboy and Ayala 1980) are two sugarcane nematodes that have been described as having some association with root pathogens.

A considerable amount of information on sugarcane nematodes in Florida was published during the 1960s by J. A. Winchester (University of Florida at Belle Glade). Winchester reported eleven different types of nematodes including both endoparasitic and ectoparasitic species during the course of his studies (Winchester 1964a, 1964b, 1965, 1966, 1968). The root-knot nematodes *Meloidogyne incognita* and *M. arenaria thamesi* are endoparasitic and may often be common and injurious in Florida sugarcane (Winchester 1966). Other endoparasitic nematodes reported to infest Florida sugarcane are the lance (*Hoplolaimus*) and lesion (*Pratylenchus*) nematodes. Reported ectoparasitic nematodes of sugarcane in Florida are the sheath (*Hemicycliophora*), sheathoid (*Hemicriconemoides*), ring (*Criconemoides*), spiral (*Helicotylenchus*), awl (*Dolichodorus*), stubby-root (*Trichodorus*), stunt (*Tylenchorhynchus*), sting (*Belonolaimus*), and *Rotylenchus* nematodes.

Although Winchester published information on the types of nematodes that may infest sugarcane in Florida, little is known regarding common infestation levels of these nematodes. In addition, the sugarcane growing region in Florida has been expanded since the 1960s, particularly into sandier soils, and information on the types and levels of nematodes in sandy areas is of interest. The growth and yield (tonnage) of sugarcane grown on sandy soils is generally much poorer than of sugarcane grown on the organic soils in Florida, and nematode damage may sometimes be one of the contributing factors. Presented here is a summary of the types and levels of plant-parasitic nematodes we observed in sugarcane fields sampled in Florida during 1983-1989.

MATERIALS AND METHODS

The data presented are a compilation from 248 samples taken from 74 commercial fields sampled during 1983-1989 across Hendry and Palm Beach counties. Approximately 45% of the fields were grown on muck soil (> 45% organic matter), 45% were grown on sand (> 95% silica), and 10% were grown on a sand-muck mix. The primary sugarcane varieties sampled during the survey were CL 59-1052, CL 61-620, CP 70-1133 and CP 72-1210. The survey was not designed to investigate differences in nematode levels among sugarcane varieties or seasonal fluctuations in nematode levels. A general assessment of nematode densities relative to crop age was made using data from 74 field-samples taken in 57 fields sampled during the four-month period November through February.

One location approximately 300 sq meters in size was usually sampled in an individual field, but as many as 10 such areas were sometimes sampled in a field. A soil sampling tube (2.4 cm diameter) was used along a row to a depth of about 17 cm to collect a sample of soil and roots for nematodes. Ten such samples were usually taken at a location along a diagonal across rows; the 10 samples were mixed together in a plastic bag, placed in a cooler, and transported to a laboratory. During 1983-1985, the majority of samples collected were mailed for a nematode assay to nematologists with the Florida Cooperative Extension Service, IFAS, University of Florida, in Gainesville. We assayed most samples taken during 1986-1989. Our assays were conducted using a sugar flotation - centrifugation method similar to the one discussed by Ayoub (1980) to extract nematodes from soil; a modified 2-day Baermann's funnel technique (Ayoub 1980) was used to extract nematodes from root samples. Each of the 248 field-samples was assayed for nematodes in soil and 143 of the samples were assayed for nematodes in roots. For crop-age comparisons, each of the 74 field-samples were assayed for nematodes in soil and 37 were assayed for nematodes in roots. The objectives of the assays were to identify the extracted plant-parasitic nematodes to the genus level and to estimate their population densities per 100 ml soil or per 10g roots.

RESULTS AND DISCUSSION

Fourteen genera of plant-parasitic nematodes were observed in samples of soil and roots from the commercial sugarcane fields. The twelve most common genera are presented in Table 1. Winchester (1964a, 1964b, 1965) observed each of these in sugarcane during the 1960s except sheathoid and one genus of spiral nematodes (*Peltamigratus*). We observed relatively few *Peltamigratus* and sting nematodes during the survey. In addition to the nematodes listed in Table 1, *Trilineelus* and *Aglenchus* nematodes were sometimes detected in sugarcane fields; the feeding habits of these nematodes were not known.

A summary of nematode levels in sugarcane grown on sand versus muck soil is presented in Figures 1-5. Sheath, sheathoid, awl, and lance nematodes were only detected in fields grown on sand. Densities of root-knot and stubby-root nematodes were generally greater in fields grown on sand than on muck. The stunt nematode was generally most prevalent in muck soils. Spiral, ring, and lesion nematodes were often as numerous in muck soil as in sand soil. No *Rotylenchus reniformis* nematodes (see Winchester 1964a) were observed during the survey. With respect to densities of endoparasitic nematodes inside roots, large densities of lesion or root-knot nematodes per 10g roots were sometimes observed, especially in fields of sugarcane grown on sand. Figures 1-5 provide an overview of nematode levels in sugarcane grown in Florida and provide a base to which future samples can be compared. No data were available concerning the densities at which nematodes may reduce growth or yield, but infestation levels of most genera were sometimes so large that economic damage may have been occurring, particularly with respect to lesion, root-knot, lance, sheath, stubby-root, and stunt nematodes. While ring and spiral nematodes were sometimes numerous, relatively large densities of these two nematodes may sometimes cause little growth reductions in at least some varieties (Hall and Irey, unpublished data).

Table 1. Plant-parasitic nematodes associated with sugarcane in Florida.

Common name	Genus	Probable species[a]
Awl	*Dolichodorus*	*heterocephalus*
Lance[b]	*Hoplolaimus*	*coronatus*
Lesion[b]	*Pratylenchus*	*brachyurus*
Ring	*Criconemoides*	*similis*
Root-knot[b]	*Meloidogyne*	*incognita acrita,* *arenaria thamesi*
Sheath	*Hemicycliophora*	*parvana*
Sheathoid	*Hemicriconemoides*	*?*
Spiral	*Helicotylenchus*	*nannus*
Spiral	*Peltamigratus*[c]	*?*
Sting	*Belonolaimus*[c]	*longicaudatus*
Stubby-root	*Trichodorus*	*christiei*
Stunt	*Tylenchorhynchus*	*martini*

[a] Species observed by Winchester (1964a, 1965).

[b] Endoparasitic nematodes.

[c] Low levels of these nematodes were observed in some fields.

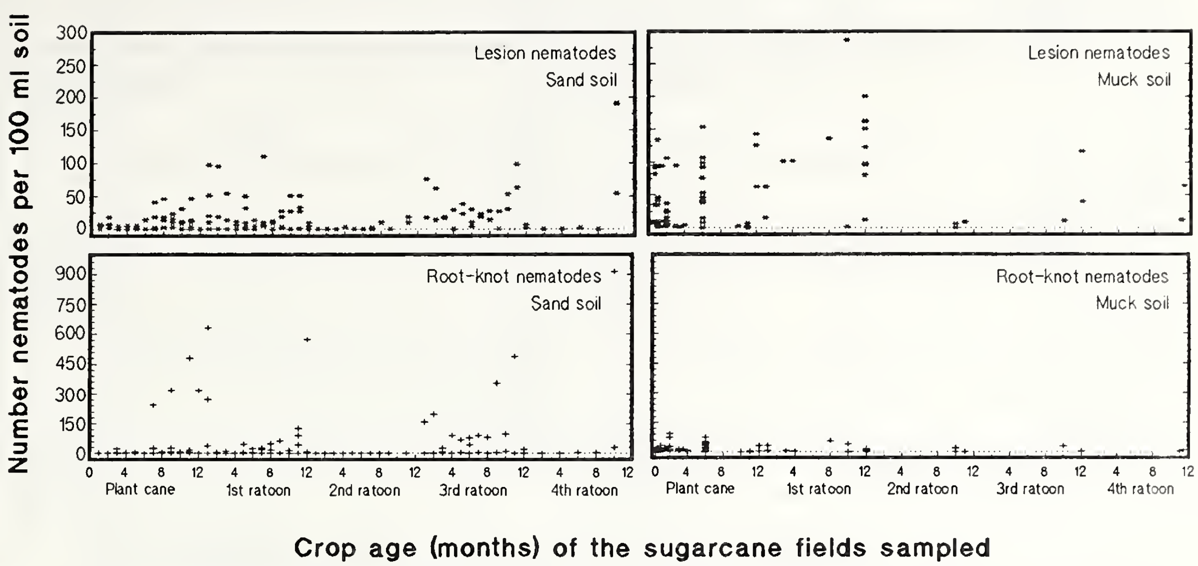

Figure 1. Population densities per 100 ml soil of lesion (*Pratylenchus*) and root-knot (*Meloidogyne*) nematodes in 248 samples from commercial sugarcane fields sampled during 1983-1989. The densities are plotted against crop age, fields grown on sand versus muck soil.

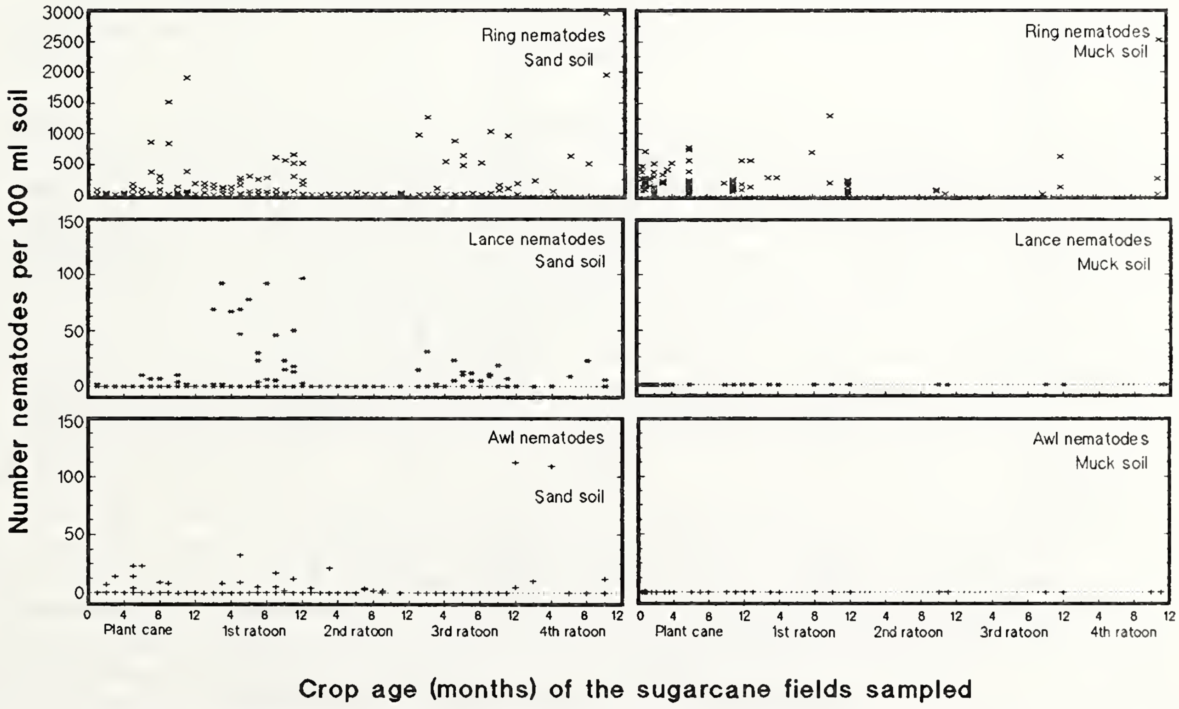

Figure 2. Population densities per 100 ml soil of ring (*Criconemoides*), lance (*Hoplolaimus*), and awl (*Dolichodorus*) nematodes in 248 samples from commercial sugarcane fields sampled during 1983-1989. The densities are plotted against crop age, fields grown on sand versus muck soil.

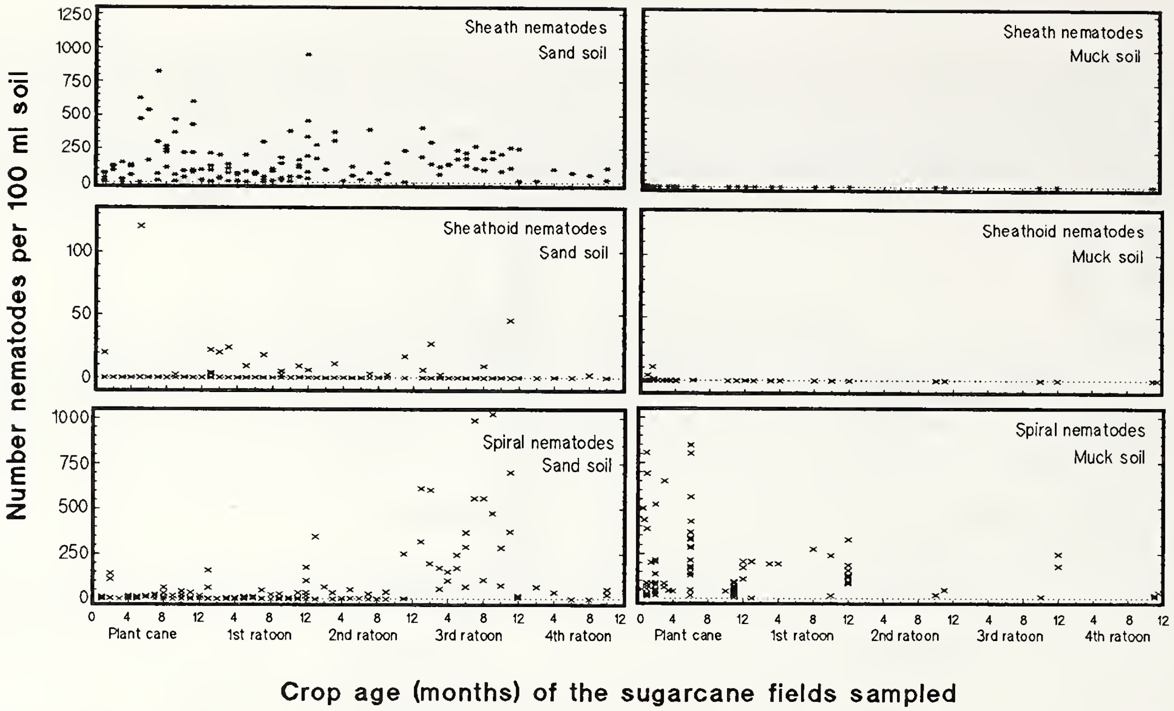

Figure 3. Population densities per 100 ml soil of sheath (*Hemicycliophora*), sheathoid (Hemicriconemoides), and spiral (primarily *Helicotylenchus* but also *Peltamigratus*) nematodes in 248 samples from commercial sugarcane fields sampled during 1983-1989. The densities are plotted against crop age, fields grown on sand versus muck soil.

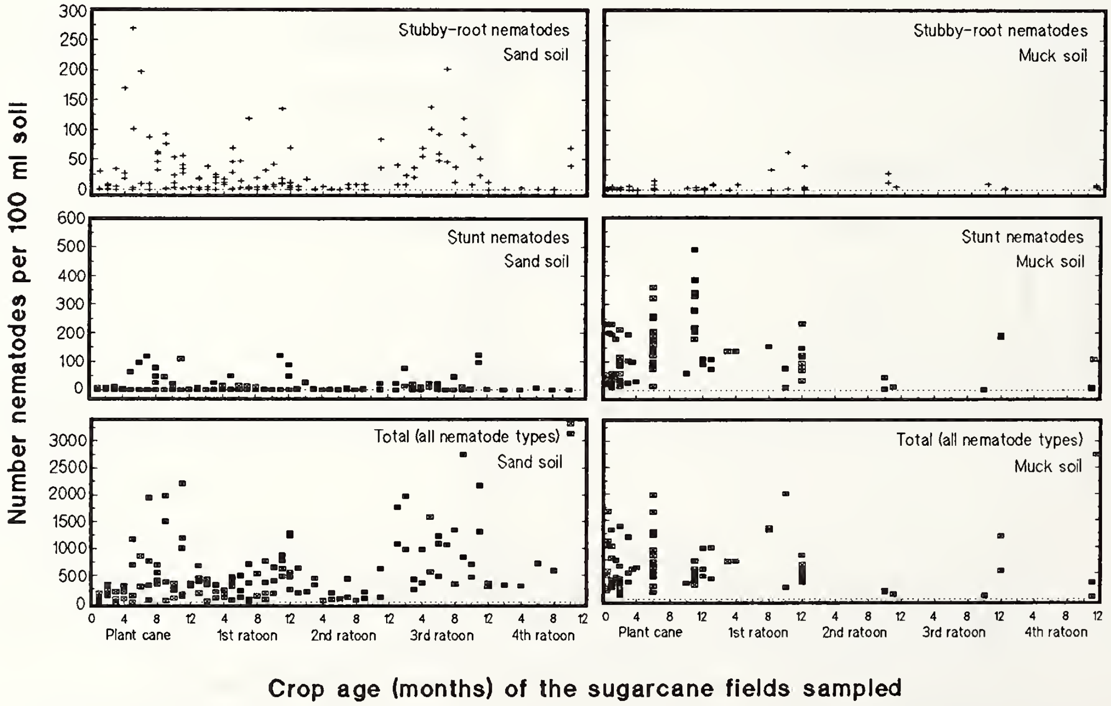

Fig. 4. Population densities per 100 ml soil of stubby-root (*Trichodorus*) and stunt (*Tylenchorhyncus*) nematodes along with the density of all types of nematodes present per sample from 248 samples from commercial sugarcane fields sampled during 1983-1989. The densities are plotted against crop age, fields grown on sand versus muck soil.

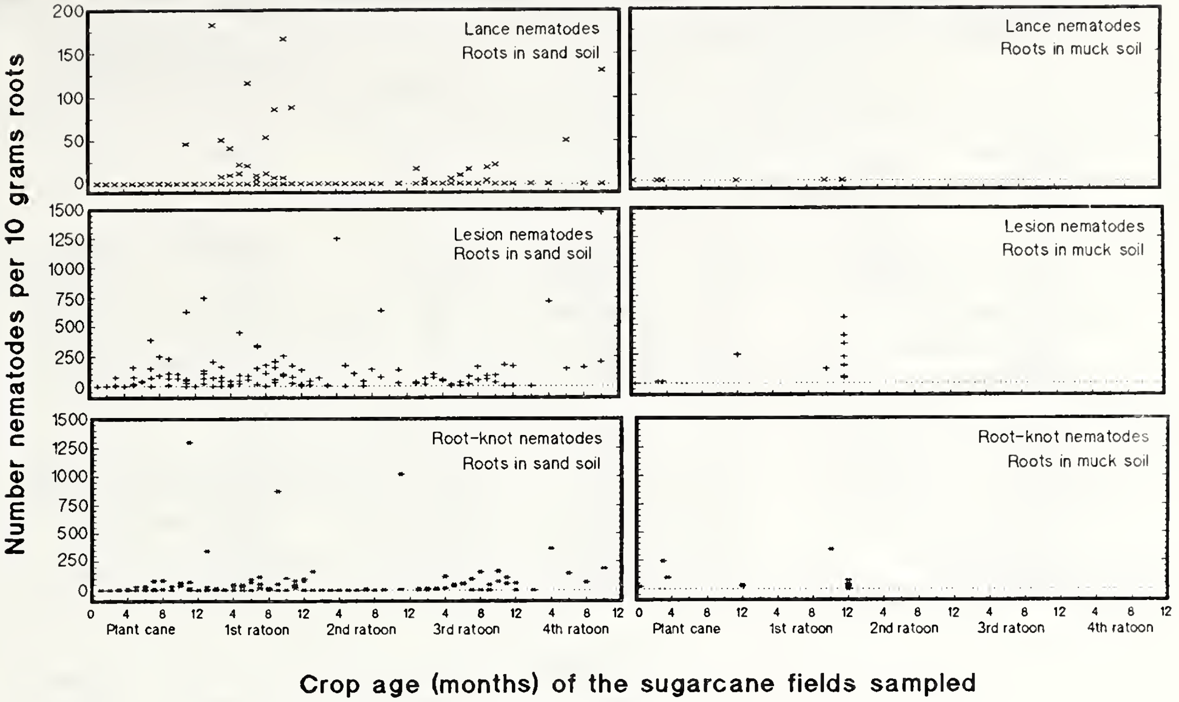

Figure 5. Population densities per 10g roots of lance (*Hoplolaimus*), lesion (*Pratylenchus*), and root-knot (*Meloidogyne*) nematodes in 143 samples from commercial sugarcane fields sampled during 1983-1989. The densities are plotted against crop age, fields grown on sand versus muck soil.

Nematode levels were generally lower in young plant-cane, but their levels in older plant cane were often as large as in second and third ratoon cane (Tables 2 and 3). This trend was evident based on all data collected during the survey (Figures 1-5). Nematode densities may generally be present at lower densities during the first 16 weeks after a field is planted, but not always (Tables 2 and 3). Cultural strategies prior to planting sugarcane may greatly influence nematode levels in young plant-cane. For example, we found that nematode levels were often large during the first 16 weeks of a plant-cane crop when the field had been successively planted to sugarcane 4 to 6 weeks after an older ratoon crop had been disked out. In contrast, fewer nematodes were generally present in young plant-cane planted after an extended fallow period; in one survey, nematode levels in fields that were fallowed from March through October were 54% lower at the end than at the beginning of the fallow period (Hall, unpublished data). Apparently as a result of the prolonged flooding associated with growing a plant and ratoon crop of rice, nematode levels in young plant-cane planted after the rice crops were 55% lower than in young cane planted in adjacent fields fallowed during the rice crops (Hall, unpublished data). Flooding generally appeared to provide less control of stunt nematodes than of some other nematodes. All young plant-cane fields sampled for nematodes during the survey had received an infurrow application of a granular pesticide at planting time, yet nematode levels in some of these fields were relatively large during early plant-cane growth (Tables 2 and 3). Whether or not granular pesticides registered for use in cane provide satisfactory nematode control in Florida sugarcane needs verification. Cultural practices and the growing of nematode-resistant sugarcane clones may be the best management strategies for sugarcane nematodes in Florida.

Table 2. Average population levels (x) per 100 ml soil of various plant-parasitic nematodes observed during November through February in commercial sugarcane fields in Florida, s = standard deviation.

			Spiral	Sheath	Stunt	Ring
Soil	Crop age	n	x(s)	x(s)	x(s)	x(s)
Muck	Plant, < 4 months	21	110(156)	0(-)	66(58)	162(172)
	Plant, > 4 months	7	107(80)	0(-)	97(37)	274(157)
	First ratoon	10	145(89)	0(-)	103(62)	247(375)
	Second ratoon	3	29(16)	0(-)	21(22)	58(32)
	Third ratoon	3	145(124)	0(-)	127(108)	258(328)
Sand	Plant, < 4 months	10	28(52)	43(42)	2(3)	16(28)
	Plant, > 4 months	7	6(8)	200(161)	10(25)	232(358)
	First ratoon	8	26(47)	219(182)	23(32)	154(150)
	Second ratoon	2	150(212)	173(118)	7(9)	8(9)
	Third ratoon	3	266(261)	184(93)	28(23)	285(357)

			Stubby-root	Lesion	Lance	Root-knot
			x(s)	x(s)	x(s)	x(s)
Muck	Plant, < 4 months	21	1(1)	22(29)	0(-)	18(23)
	Plant, > 4 months	7	3(4)	71(61)	20(54)	6(4)
	First ratoon	10	12(21)	125(85)	0(-)	7(13)
	Second ratoon	3	15(11)	5(5)	0(-)	6(11)
	Third ratoon	3	4(4)	56(55)	0(-)	12(16)
Sand	Plant, < 4 months	10	5(10)	4(6)	1(1)	1(1)
	Plant, > 4 months	7	26(21)	14(19)	1(1)	122(196)
	First ratoon	8	20(24)	13(20)	11(25)	77(130)
	Second ratoon	2	31(18)	7(3)	0(-)	1(1)
	Third ratoon	3	24(26)	39(33)	5(8)	88(140)

Table 3. Average population levels (x) per 10g roots of lesion, lance, and root-knot nematodes observed during November through February in commercial sugarcane fields in Florida, s = standard deviation.

			Lesion	Lance	Root-knot
Soil	Crop age	n	x(s)	x(s)	x(s)
Muck	Plant, < 4 months	2	7(10)	0(-)	133(159)
	Plant, > 4 months	3	167(132)	0(-)	54(42)
	First ratoon	8	240(177)	0(-)	66(116)
Sand	Plant, < 4 months	4	0(-)	0(-)	0(-)
	Plant, > 4 months	7	41(49)	7(17)	201(486)
	First ratoon	8	82(157)	12(32)	27(27)
	Second ratoon	2	52(27)	0(-)	299(417)
	Third ratoon	3	68(24)	4(8)	58(31)

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VARIATION FOR JUICE QUALITY AND FIBER CONTENT IN CROSSES BETWEEN COMMERCIAL SUGARCANE AND *SACCHARUM SPONTANEUM*

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ABSTRACT

Saccharum spontaneum has many desirable traits that may be used to improve modern sugarcane cultivars, but the species tends to have high fiber and low sucrose content. Genetic information is needed on the inheritance of fiber and juice quality characteristics to effectively make breeding plans. Data on juice quality and fiber content in the parental, F_1, F_2 and BC_1 generations from crosses between four sugarcane cultivars and eight clones of *S. spontaneum* were obtained to evaluate the genetic variability and inheritance of these characters. The distributions of Brix, sucrose content, purity and fiber content in these generations were continuous and controlled by polygenes. Analyses of genetic variance indicated that additive genetic variance was more important than dominance genetic variance for all four characters. Narrow-sense heritability of these characters was moderate; therefore, selection should be effective in improving juice quality while lowering fiber content.

INTRODUCTION

Saccharum spontaneum has played an extremely important role in the development of sugarcane varieties (12,18,22). This species has many desirable characters, including disease resistance, vigor, tillering and ratooning ability, drought resistance, cold tolerance, and wide adaptability (15, 19). Sugarcane breeders have long used this species to improve cultivated clones through inter- specific hybridization (20). The modern cultivars, however, have a very narrow genetic base, and their pedigrees trace back to two *S. spontaneum* clones (Glagah and Coimbatore) and a limited number of *S. officinarum* clones (25). The difficulties encountered in utilizing sugarcane germplasm include non-flowering and flowering synchronization problems. Photoperiod adjustment (14) and pollen storage (24) have been used to overcome, to some extent, these difficulties.

In spite of their many desirable characters, most clones of *S. spontaneum* have low sucrose content and high fiber content (16,20,27). Hybrids of commercial cultivars x *S. spontaneum* have reduced the sucrose content and increased fiber content (2,16,17,18,28). Based on the F_1, BC_1, and BC_2 progenies of the crosses between *S. officinarum* and *S. spontaneum*, Roach (16,18) reported that sucrose and fiber content had moderate to high heritability. Stevenson (22) suggested that juice Brix was controlled by polygenes in crosses between noble and commercial canes. Hogarth (8,9) found that additive genetic variance was much more important than non-additive variance in determining Brix. Brown et al. (5) reported that narrow-sense heritability of fiber fresh weight was moderate ($h^2 = 0.34 \pm 0.15$), and similar to the heritability value ($h^2 = 0.45$) estimated by Hogarth (10).

To effectively use *S. spontaneum* germplasm in sugarcane cultivar improvement programs, genetic information on the various characters of economic importance is needed. Sugarcane breeders can then develop sound selection strategies and an effective nobilization process. The objectives of this study were to assess the genetic variability of juice quality and fiber content in F_1, F_2, and BC_1 generations in crosses between commercial sugarcane cultivars and *S. spontaneum* and to estimate heritability on a family basis for these characters.

MATERIALS AND METHODS

During the 1987/88 flowering season, F_1 hybrids derived from crosses between commercial sugarcane cultivars and *S. spontaneum* (24) were self-fertilized to produce F_2 seed. BC_1 seed was produced by backcrossing the F_1 hybrids to commercial cultivars (CP 70-1133, CP 76-331 and CP 68-

350) or to a noble (*S. officinarum* Sylva). The term backcross is used in this study in a general rather than a strict genetic sense, and implies crossing back to a commercial cultivar. F_1 seed from three crosses, CP 65-357 x SES 390, CP 65-357 x Coimbatore and CP 65-357 x US 56-15-8, were used for this investigation. The F_1, F_2, and BC_1 seed were planted in the greenhouse in January 1988 and seedlings were transplanted to the field at Canal Point, Florida in June 1988. A randomized complete block design with 15 replications was used for this experiment. Five seedlings from each family were planted at 0.3m intervals as a single row plot with 1.5m between plots and rows. Two to three seedlings were sampled from each plot and five to ten stalks were cut from each of these seedlings as a sample for milling and juice analysis in January 1989. Stalks were macerated with a Jeffco Cutter-Grinder[1] (11). Two subsamples of an average of 120g each were taken from each macerated sample for measurement of fiber content. The remainder of the sample was pressed in a laboratory press to extract juice on which quality measurements were made: Brix, sucrose (%) and purity. Fiber content was determined by washing the macerated samples (in cloth bags) for three cycles in an automatic washing machine, and drying to constant weight at 105°C (11). Fiber (%) was calculated directly from fresh and dry sample weights. Brix was obtained using an automatic refractometer. Sucrose (%) was calculated from the polarization and use of the Schmitz Table to convert to sucrose content (13). Purity was calculated as the ratio of sucrose (%) to Brix [(sucrose % /Brix) x 100]. Plot means were used for the analysis of variance and individual plant values were used to estimate the variation between individuals within plots (3).

The analyses of variance (23) were carried out for the combination of F_2 and BC_1 families. Among these eight BC_1 families derived from crosses between F_1 hybrids (CP 65-357 x SES 390, CP 65-357 x Coimbatore, and CP 65-357 x US 56-15-8) and three recurrent parents (Sylva, CP 68-350, and CP 81-331), 3 x 2 and 2 x 3 sets of crosses were used separately to estimate variance components for the four characters examined (3).

Heritability estimates (h^2) were calculated from variance components (3,7). Narrow-sense heritability of juice quality and fiber content was estimated as:

$$h_m^2 = 4\,\sigma_m^2/\sigma_p^2,$$

$$h_f^2 = 4\,\sigma_f^2/\sigma_p^2, \text{ and}$$

$$h^2_{(m+f)} = 2\,(\sigma_m^2 + \sigma_f^2)/\sigma_p^2$$

where h_m^2 = estimate of heritability based on the male component, h_f^2 = estimate of heritability based on female component; h^2_{m+f} = estimate of heritability based on male and female components, σ_p^2 (phenotypic variance) = $\sigma_m^2 + \sigma_f^2 + \sigma_{mf}^2 + \sigma_w^2$, σ_m^2 = the variance component due to *S. spontaneum* male parents, σ_f^2 = the variance component due to the commercial sugarcane cultivar female parents, σ_{mf}^2 = the variance component for male x female interaction and σ_w^2 = the variance component of individual plants within plot. Estimates of additive genetic variance (σ_A^2) were calculated as $2\,(\sigma_m^2 + \sigma_f^2)$ and estimates of dominance genetic variance (σ_D^2) were calculated as $4\sigma_{mf}^2$, assuming no epistasis (9,10). The expected genetic advance (G_s) under selection (1) for high sugar content and lower fiber content in the populations of 2 x 3 and 3 x 2 sets of crosses is:

$$G_s = 100\,(k)\,(\sigma_p)\,(h^2_{m+f})/\text{ mean}$$

where k (selection intensity) = 2.06, assuming 5 percent of the seedlings were saved.

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[1] Mention of a trademark, vendor, or proprietary product does not constitute a guarantee or warranty of the product by the USDA and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

RESULTS AND DISCUSSION

The male parents (*S. spontaneum* clones) had a marked effect on the F_1 hybrids, which all had lower juice quality and higher fiber content than did their female parents (commercial sugarcane cultivars) (Table 1). Brix, sucrose content and purity were below the calculated mid-parent values in most crosses. These results agreed with those of Tai et al. (27) for F_1 hybrids from crosses between three commercial sugarcane cultivars and three *S. spontaneum* clones, and those of Roach (15) for F_1 hybrids from crosses between two nobles and four *S. spontaneum* clones.

F_2 populations generally produced wider ranges of distribution, and lower mean values for juice quality than did the BC_1 populations (Table 2). However, for fiber content, most F_2 populations had higher mean values than did the BC_1 populations. Mean Brix values between F_2 and BC_1 populations were similar. Among BC_1 populations, progenies derived from the backcrosses to the recurrent parent, CP 70-1133, tended to have higher juice quality and fiber content than did the BC_1 populations derived from three other recurrent parents.

The frequency distributions of sucrose and fiber content were further examined in the F_2 and BC_1 generations. On average, the BC_1 populations had higher frequencies of plants (33.11%) with sucrose content $\geq$ 11.5% than did the F_2 populations (22.54%). The modes of the BC_1 populations were located about 2% more toward the higher range of sucrose content than were those of the F_2 populations. Among four recurrent parents, CP 70-1133 produced BC_1 progenies with the highest average sucrose content (11.42%) and Sylva produced BC_1 progenies with the lowest sucrose content (8.29%). For progenies with fiber content $\leq$ 12.5%, the average of the BC_1 population had about 46.18%, while that of the F_2 populations had about 5.55%.

The distribution of sucrose and fiber content in both F_1 and BC_1 populations from CP 65-350 x SES 390 cross and F_1's from two other crosses appeared normal (Figs. 1 and 2). The BC_1 populations from two crosses, CP 65-357 x US 56-15-8 and CP 65-357 x Coimbatore, had modes at a higher range of sucrose content and were skewed markedly toward the lower range of sucrose content. The fiber content of F_1 and BC_1 populations were markedly skewed toward the lower range. In all three crosses, F_1 populations had a wider range in fiber content than did the BC_1 populations.

Brix and purity of the F_1 hybrids had slightly greater than half (50%) of the standard, CP 65-357, which was assumed to be 100% in each of the four characters examined (Table 3). The other two characters, sucrose and fiber content, were slightly less than half of the standard. There was a marked increase in the juice quality from the F_1 to the BC_1 generation and the fiber content declined significantly between the F_1 and BC_1 generations. Of the three measurements of the juice quality, the change in sucrose content from the F_1 to the BC_1 generation was not as large as were changes in the other two characters. Similar results were obtained from the backcrossing study of sugarcane intergeneric hybrids (26).

The results indicated that backcrossing of the F_1 hybrids to commercial sugarcane cultivars or nobilization with commercial cultivars were very effective procedures to increase sucrose content and to decrease fiber content of the interspecific hybrids. Similar results were reported in a nobilization study of sugarcane intergeneric hybrids involving *Erianthus* and *Miscanthus* (26). Based on the characteristics of F_2 and BC_1 frequency distributions and the response of the F_1 hybrids when backcrossed to the commercial cultivars, the inheritance of juice quality and fiber content is controlled by multiple genes. Stevenson (22) also made a similar suggestion regarding the number of genes governing the sucrose content and fiber content. Mariotti et al. (12) estimated that Brix was controlled by 2 to 9 loci (effective factors). Most of the commercial sugarcane cultivars, such as those used in this study, have been selected intensively for high sucrose content and low fiber content for several generations (4). Whether these two characters have become highly homozygous needs to be further examined. Sugarcane is a complex polyploid (21,22), but inheritance appears to be of a diploid nature (10).

Table 1. Juice quality and fiber content of the parents and their hybrids with *S. spontaneum* clones.

Parents or Crosses	Brix (°)	Sucrose(%)	Purity (%)	Fiber (%)
Females:Commercial Sugarcane				
CP 65-357	21.20±0.36	19.40±0.77	91.19± 0.34	12.73±0.65
CP 73-378	17.99±0.23	15.75±0.61	87.59± 0.59	13.52±0.10
CP 79-302	19.93±0.47	17.64±0.70	88.49± 0.44	13.24±0.52
CP 80-1902	18.73±0.35	16.60±0.18	88.63± 0.45	12.85±0.30
POJ 2725	12.93±0.41	9.46±0.24	73.18± 0.80	12.00±0.24
Males:*S. spontaneum*				
Coimbatore (PI 3700)	6.82±0.45	2.61±0.23	38.41± 1.78	28.55±0.62
Karenko (PI 2372)	8.86±0.25	2.93±0.06	33.02± 0.51	32.68±0.40
28 NG 292 (PI 0876)	8.72±0.31	3.46±0.02	39.76± 1.23	29.35±1.14
SES 390 (PI 3792)	13.55±0.30	7.34±0.09	54.21± 1.12	32.65±0.26
Tainan 2n=96(PI 1324)	10.92±0.11	5.63±0.37	51.56± 3.91	27.24±0.96
US 56-15-8 (PI 9261)	12.11±0.07	6.73±0.14	55.99± 0.82	32.37±0.13
F_1 hybrids				
CP 65-357 x Coimbatore	10.41±0.80	4.79±1.24	45.03± 2.78	25.20±3.62
CP 65-357 x 28 NG 292	12.40±0.60	7.99±1.34	64.44± 8.06	23.02±0.88
CP 65-357 x SES 390	12.54±1.61	6.61±1.72	50.68±10.68	18.34±0.42
CP 65-357 x US 56-15-8	8.88±1.59	4.07±1.35	36.83± 7.31	14.42±1.30
CP 65-357 x Uganda	13.90±1.25	9.47±0.51	68.13±10.35	25.68±3.85
CP 72-378 x US 56-15-8	11.40±0.20	6.86±0.20	60.18± 1.70	24.45±0.62
CP 74-302 x Karenko	9.40±3.68	4.42±2.80	47.02± 5.68	----------
CP 74-302 x 28 NG 292	12.40±1.46	8.47±1.32	68.31± 6.30	22.88±2.36
CP 80-1902 x Tainan 2n=96	12.50±1.20	7.55±1.22	60.40± 0.50	20.42±0.92
CP 80-1902 x US 56-15-8	15.60±2.52	9.55±1.76	61.22± 9.56	20.12±2.50
POJ 2725 x Coimbatore	11.20±1.32	6.21±0.24	55.45± 1.24	21.12±1.54
POJ 2725 x SES 246	11.00±0.60	6.13±0.88	55.72± 5.61	17.02±2.12

Table 2. Means for juice quality and fiber content in the F_2 and BC_1 generations in crosses between commercial sugarcane cultivar and *Saccharum spontaneum*.

Cross	Brix (%)	Sucrose (%)
F_2 Generation		
CP 80-1902 x Tainan 2n=96	15.51± 1.64	7.81±2.38
CP 79-302 x Karenko	15.44± 2.39	5.39±2.44
POJ 2725 x Coimbatore	18.67± 6.49	12.23±5.37
CP 72-378 x US 56-15-8	14.07± 1.59	6.04±2.62
CP 65-357 x Coimbatore	15.34± 5.29	7.44±3.06
CP 79-302 x 28 NG 292	16.30± 1.84	11.11±2.67
Average	15.89± 3.11	8.34±3.17
BC_1 Generation		
(CP65-357x28 NG292) x CP70-1133	16.71± 1.29	12.07±2.20
(CP65-357x Uganda) x CP70-1133	16.55± 1.48	11.75±1.65
(POJ 2725x SES 246) x CP70-1133	15.64± 5.32	10.49±3.80
(CP80-1902xUS56-15-8)xCP70-1133	16.70± 5.73	11.63±4.98
(CP65-357xCoimbatore)xCP70-1133	15.63± 1.40	11.16±1.53
(CP65-357x SES 390) x Sylva	13.73± 1.60	8.86±1.51
(CP65-357xSES 390) x CP 76-331	14.50± 1.42	9.95±1.40
(CP65-357xSES 390) x CP 68-350	14.38± 1.60	9.71±1.73
(CP65-357xUS56-15-8)x Sylva	13.48± 1.43	7.28±2.64
(CP65-357xUS56-15-8)x CP 76-331	13.88± 4.87	9.02±3.37
(CP65-357xUS56-15-8)x CP 68-350	15.13± 4.18	9.22±3.63
(CP65-357xCoimbatore)x Sylvia	14.32± 1.20	8.74±2.40
(CP65-357xCoimbatore)x CP76-331	14.56± 1.36	9.79±2.48
Average	15.02± 2.53	9.97±2.31
F_2 Generation	Purity (%)	Fiber (%)
CP 80-1902 x Tainan 2n=96	50.08±13.58	18.05±2.43
CP 79-302 x Karenko	35.26±14.42	19.98±2.72
POJ 2725 x Coimbatore	65.54±26.86	17.17±6.43
CP 72-378 x US 56-15-8	42.44±16.82	17.17±2.25
CP 65-357 x Coimbatore	48.72±19.55	20.44±7.26
CP 79-302 x 28 NG 292	67.77±13.70	16.40±1.58
Average	51.72±18.02	18.20±3.72
BC_1 Generation		
(CP65-357x28 NG292) x CP70-1133	72.04±10.22	15.99±3.93
(CP65-357x Uganda) x CP70-1133	70.94± 7.27	16.80±1.91
(POJ 2725x SES 246) x CP70-1133	66.80±23.25	15.19±5.28
(CP80-1902xUS56-15-8)xCP70-1133	70.38±29.43	15.03±5.15
(CP65-357xCoimbatore)xCP70-1133	71.14± 5.23	13.49±2.01
(CP65-357x SES 390) x Sylva	64.34± 5.79	16.06±1.79
(CP65-357x SES 390) x CP 76-331	68.72± 7.67	14.17±1.88
(CP65-357x SES 390) x CP 68-350	67.08± 5.80	15.63±1.88
(CP65-357xUS56-15-8)x Sylva	64.74±24.10	13.97±4.93
(CP65-357xUS56-15-8)x CP 76-331	53.88±19.04	14.24±2.18
(CP65-357xUS56-15-8)x CP 68-350	61.12±24.72	13.03±1.49
(CP65-357xCoimbatore)x Sylvia	61.06±16.79	14.34±1.35
(CP65-357xCoimbatore)x CP76-331	67.63±17.48	14.18±1.83
Average	66.14±15.50	14.81±22.74

The estimates of σ_m^2, σ_f^2, and σ_{mf}^2 were relatively small for each of the traits as compared with the corresponding estimate of σ_w^2. The estimates of σ_m^2 for all characters examined except purity were generally greater than the estimates of σ_f^2 except for fiber (Table 4). The results suggested that the differences between male parents (recurrent parents including noble and commercial cultivars) were greater than between female parents (F_1 hybrids of commercial sugarcane cultivar x *S. spontaneum* crosses) for these three characters of juice quality. The significant male effect could be due to the different genotypic effect between noble and commercial cultivar parents. The results also indicated that the genetic differences for fiber content among male and female parents contributed to the progeny variation. Mean squares of male x female interactions, were not significant for any character examined except fiber content which was significant in a 3 x 2 set of crosses. These results suggested that genes for juice quality and possibly for fiber content acted additively. Whether the F_1 hybrids from crosses between commercial cultivars and *S. spontaneum* clones would produce irregular transmission of *S. spontaneum* chromosomes and genetic effects needs to be examined. Since the data were obtained from single test, (one location for one year), the estimate of σ_m^2, σ_f^2, and σ_{mf}^2 were possibly confounded with

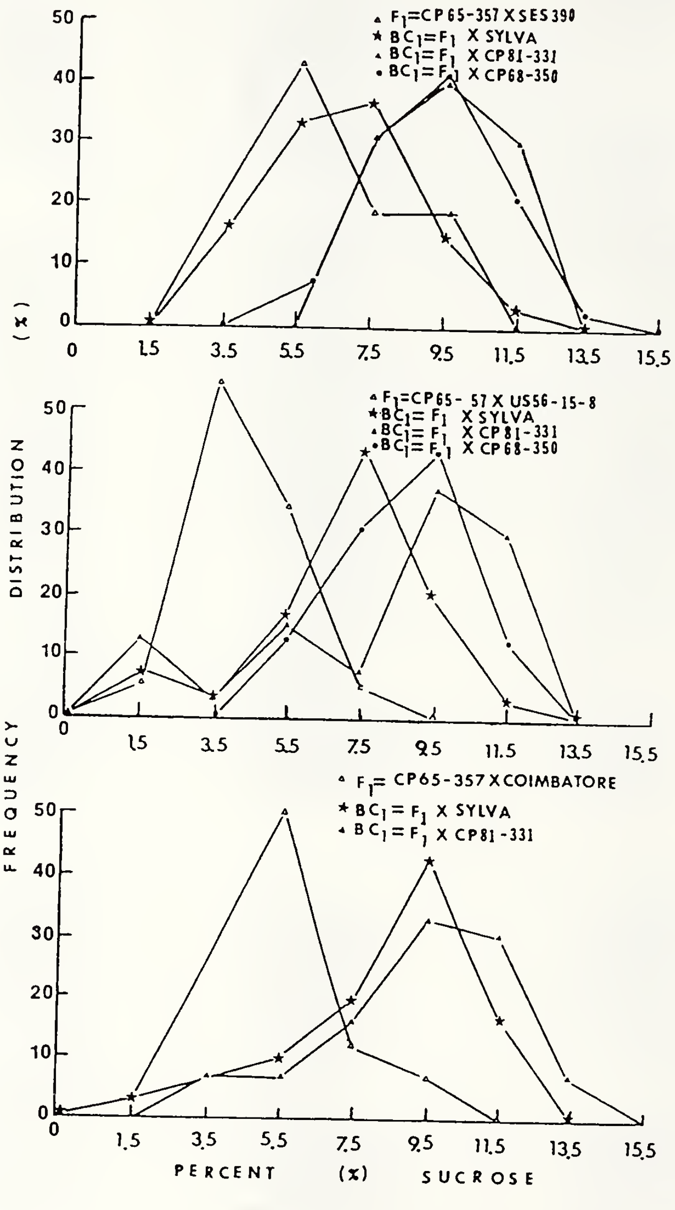

Fig. 1. Frequency distribution for sucrose content in the F1 and BC1 generations in crosses between one commercial sugarcane cultivar and three S. spontaneum clones.

Fig. 1. Frequency distribution for sucrose content in the F1 and BC1 generations in crosses between one commercial sugarcane cultivar and three *S. spontaneum* clones.

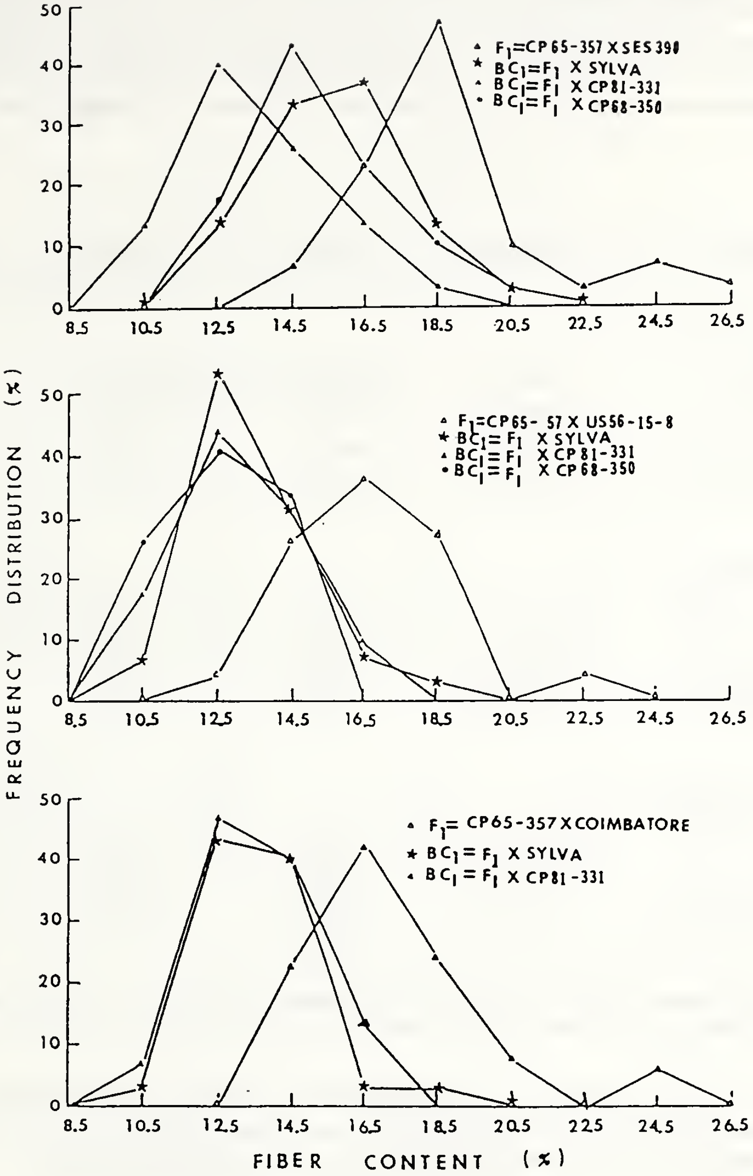

Fig. 2. Frequency distribution for fiber content in the F1 and BC1 generations in crosses between one commercial sugarcane cultivar and three S. spontaneum clones.

Fig. 2. Frequency distribution for fiber content in the F1 and BC1 generations in crosses between one commercial sugarcane cultivar and three *S. spontaneum* clones.

Table 3. Comparison with the juice quality and fiber content of the standard variety, CP 65-357, in the F_1 and BC_1 generations of the commercial sugarcane x *S. spontaneum* crosses.

Cross	Brix	Sucrose Content	Purity	Fiber Content
		%		
CP65-357 (check)[1/]	100.00	100.00	100.00	100.00
CP65-357xSES 390				
F_1	59.15	34.07	55.58	144.07
$BC_1 = F_1$ x Sylva	64.76	45.67	70.56	126.16
$BC_1 = F_1$ x CP 76-331	68.40	46.13	75.36	111.31
$BC_1 = F_1$ x CP 68-350	67.83	50.05	73.56	122.78
CP65-357xUS 56-15-8				
F_1	41.89	20.98	40.39	113.28
$BC_1 = F_1$x Sylva	63.59	37.52	70.99	109.74
$BC_1 = F_1$x CP 76-331	65.47	46.49	59.08	111.86
$BC_1 = F_1$x CP 68-350	71.36	47.52	67.02	102.36
CP65-357 x Coimbatore				
F_1	49.10	24.69	49.38	197.96
$BC_1 = F_1$ x Sylva	67.55	45.05	66.96	112.65
$BC_1 = F_1$ x CP 76-331	68.68	50.46	74.16	111.39

[1/] The measurements of CP 65-357, the standard for the test, which was assumed to be 100.00%, Brix 21.20, sucrose 19.40%, purity 91.19% and fiber content 12.73%.

the various interaction components. The estimates of genetic variance indicated that additive genetic variance (σ_A^2) was more important than dominance genetic variance (σ_D^2) for all characters examined (Table 4). A number of the σ_D^2 estimates were negative (essentially zero).

Heritability estimates based on both male and female components ($h^2_{m+f} = 2(\sigma_m^2 + \sigma_f^2)/\sigma_p^2$) produced more consistent estimates for these characters from both 3 x 2 and 2 x 3 sets of crosses than the estimates based on the male or female estimates alone (Table 4). The results indicated that the heritability of all four characters was moderate. Under the selection intensity of five percent seedlings saved, the estimated genetic advance (G_s) expressed in percent of the population mean was 15.58% for sucrose content and 5.65% for fiber content from 3 x 2 set of crosses and 13.15% for sucrose content and 9.71% for fiber content from 2 x 3 set of crosses. Therefore, selection for either high sucrose content or low fiber content would be moderately effective in the BC_1 generation.

In the Java nobilization of *S. spontaneum* Glagah (2n=112), the number of *S. spontaneum* chromosomes was reduced to 56 (Kassoer) in the first nobilization, to 28 (POJ 2364) in the second nobilization, and to 14 (POJ 2725 and POJ 2878) in the third nobilization (21). Since no cytological information was available for this study, we do not know whether or not the transmission of the *S. spontaneum* chromosomes in commercial sugarcane cultivar x *S. spontaneum* crosses was similar to the pattern of the Java nobilization. However, preliminary results by Burner et al. (5) indicate that n + n chromosome transmission predominates in crosses at commercial cultivars x *S. spontaneum*.

Also, interspecific hybrids that show non-random recombination and segregants with characters nearer to one of the original species should have a better chance of survival in nature (1). These effects would change the inheritance patterns of many characters, including juice quality and fiber content, in sugarcane interspecific hybrids specifically the effect 2n vs. 1n genetic transmissions on the female side. This work is needed on these materials to make more accurate genetic evaluations.

Table 4. Estimate of variance components for juice quality and fiber content from two sets of backcrosses between F_1 (commercial sugarcane cultivar *x S. spontaneum*) and commercial sugarcane variety or noble.

	Components of variance				Genetic variance	
Character	$\sigma m2$+	σ_f^2	σ_{mf}^2	σ_w^2	σ_A^2	σ_D^2
3 F_1's x 2 males[1/]						
Brix	0.58**	-0.07	0.17	1.90	1.16	0.68
Sucrose(%)	1.45**	0.05	-0.10	3.53	3.00	----3/
Purity(%)	18.90	4.39	-20.40	145.64	46.58	----
Fiber(%)	0.29**	0.53**	0.19**	2.99	1.64	0.76
2 F_1's x 3 males[2/]						
Brix	0.54**	-0.05	0.04	2.33	1.08	0.16
Sucrose(%)	1.06**	0.17	-0.08	3.27	2.46	----
Purity(%)	9.29	12.26	-2.61	112.01	43.76	----
Fiber(%)	0.36**	1.12**	-0.00	3.30	2.96	----

	Estimate of heritability		
	h_m^2	h_f^2	h_{m+f}^2
3 F_1's x 2 males[1/]			
Brix	0.88±0.83	0.08±0.16	0.57±0.42
Sucrose (%)	1.14±1.28	0.04±0.13	0.61±0.51
Purity (%)	0.42±0.36	0.32±0.31	0.37±0.24
Fiber (%)	0.29±0.33	0.53±0.49	0.41±0.30
2 F_1's x 3 males[2/]			
Brix	0.74±0.60	.0	0.37±0.30
Sucrose (%)	0.94±0.73	0.15±0.17	0.55±0.38
Purity (%)	0.28±0.41	0.37±0.42	0.32±0.29
Fiber (%)	0.30±0.29	0.94±0.78	0.62±0.42

+ Variance components: σ_m^2=males, σ_f^2=females, σ_{mf}^2=female x male interaction, and σ_w^2=individual plants; Genetic variance: σ_A^2=additive and σ_D^2=dominance; Heritability: h_m^2=estimate based on male components, h_f^2=estimate based on female component, and $h_{(m+f)}^2$=estimate based on male and female components.

** Two mean squares used to estimate variance component differed significantly at 1% level.

[1/] 3 F_1's:CP 65-357 x SES 390, CP 65-357 x US 56-15-8 and CP 65-357 x Coimbatore; 2 males:CP 76-331 and Sylva.

[2/] 2 F_1's: CP 65-357 x SES 390 and CP 65-357 x US 56-15-8; 3 males: CP 68-350, CP 76-331 and Sylva.

[3/] Variance component was negative.

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PERFORMANCE OF TWELVE SUGARCANE CULTIVARS GROWN ON ORGANIC SOIL AND SUBJECTED TO MECHANICAL HARVESTING

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ABSTRACT

Sugarcane cultivars respond differently to mechanical harvesting. The object of this research was to examine the performance of current cultivars over a 3-year crop cycle. Twelve commercial and unreleased cultivars were grown in replicated plots at the Everglades Research and Education Center (EREC), Belle Glade, Florida. The cane was planted on December 22-23, 1987 and was harvested for three crops (plant, first, and second ratoon) with a combine harvester. Gross cane weight was determined for each experimental plot. Each year, a random sample of cane stalks was collected from each plot, milled in a 3-roller sample mill, and juice quality was determined from the extracted juice. Using juice quality factors and net cane weights from each plot, estimated sugar yield was calculated. Additionally, each plot of cane was rated for cane erectness/adaptability for mechanical harvesting. Significant yield differences were found among cultivars.

Differences in ratooning ability among cultivars were noticeable after 3 years of mechanical harvesting. CP 80-1827 had the best regrowth rating and the highest stalk counts in the third-ratoon crop, with CL 73-239, CP 74-2005 and CP 80-1743 also providing acceptable stands. CP 78-2114 had the poorest ratings and the lowest stalk counts in the third-ratoon crop.

INTRODUCTION

Sugarcane acreage in Florida has continued to increase since its rapid rise in the early 1970's, with approximately 440,000 acres grown for the 1990-91 crop (Coale and Glaz, 1991). Mechanical harvesting of sugarcane remained fairly constant at 26-32% of the total crop from 1975-1988 (Unpublished data from USDA, ARS, Sugarcane Harvesting Laboratory). Reasons for not increasing mechanical harvesting during this time were: (1) the continued availability of imported manual labor; (2) cane stubble was damaged by mechanical harvesters and more frequent replanting was required; and (3) producers were still assessing the reliability and real cost of mechanical harvesting. Mechanical harvesting comprised 40% of the 1990-91 crop (Florida Sugar Cane League, Personal Communication). In our opinion the increase in mechanical harvesting has occurred because recent versions of mechanical harvesters have become more reliable and effective whereas handcut costs have continued to increase. This increase in mechanical harvesting has coincided with industry expansion onto mineral soils and the utilization of cultivars more adapted to mechanical harvesting.

Clayton et al. (1982) conducted two previous experiments during 1973-78 comparing the yield performance of 17 commercial and unreleased cultivars, subjected to mechanical harvesting. Of these 17 cultivars, only three were grown commercially in 1990, representing only 17.5% of the acreage (Coale and Glaz, 1991). A new experiment, comparing 12 cultivars grown on 90% of the crop area for the 1990-91 crop (Coale and Glaz, 1991), was planned and initiated in 1987. The objective of this experiment was to evaluate the performance of these 12 cultivars over a three crop cycle on an organic soil when subjected to current mechanical harvesting equipment.

MATERIALS AND METHODS

The field for the experiment was located at the University of Florida, Everglades Research and Education Center (EREC), Belle Glade, Florida. The experimental design was a randomized-complete-block with three replications. Each plot consisted of 3 rows (15 ft. wide) of cane 200 ft. in length. Twelve cultivars (CL 61-620, CL 73-239, CP 70-1133, CP 70-1527, CP 72-1210, CP 72-2086, CP 73-1547, CP 74-2005, CP 78-1247, CP 78-2114, CP 80-1743, and CP 80-1827) were selected from commercial, recently released, and experimental cultivars, representing diverse stalk and growth characteristics. Seedcane of each cultivar was handcut and planted in organic soil (Histosol--Pahokee muck), using two continuous lines of seedcane per row, on December 22-23, 1987. The plots received herbicide spray treatments and 2-3 mechanical cultivations during each growing season. The cane in the plots was burned on the afternoon prior to harvesting. Cane in each plot was harvested using an Austoft 7700[1] combine harvester. The plant-cane crop was harvested on February 26, 1989. The first-ratoon crop was harvested on February 25, 1990 because a deterioration study was conducted using the cane damaged by the December 24-26, 1989 freeze, delaying the planned early January harvest. The second-ratoon crop was harvested on December 5, 1990. The field was not chiseled after harvest. The harvest schedule was planned to simulate a typical harvesting strategy in Florida.

For the plant-cane and second-ratoon crops, a 10-stalk random sample was collected from each plot after the preharvest fire, milled in a 3-roller sample mill within 2 days, and the extracted juice analyzed for Brix and sucrose. For the first-ratoon crop, unburned stalk samples were collected for juice analysis on December 29, 1989 before any significant deterioration caused by the severe freeze had occurred. These unburned samples were processed in a similar manner to the other samples. To approximate mechanical harvesting, all samples were topped at the top visible dewlap, ie. the immature tops were included in the mill samples and leaf trash adhering to the stalks was not removed before milling. Cane in each plot was rated for stalk erectness/machine adaptability on a scale of 1 (poor) to 10 (excellent). The stalk erectness/machine adaptability rating was a subjective attempt to rate erectness, the ease and efficiency with which stalks could be collected by the harvester gathering mechanisms and how well the stools were anchored into the soil. Root anchoring characteristics of the second-ratoon crop prior to harvest were visually rated on a scale of 1 (poor) to 4 (excellent). For instance, uprooted stools rated 1 and stools showing no evidence of uprooting rated 4. Regrowth was evaluated several months after each harvest on the basis of potential yield (tons per acre/10). Stand counts were also taken on 100 ft. of the center row of each plot. Cane from each 3-row plot was loaded into high-dump wagons, weighed on a hydraulic scale at the EREC, and loaded into highway cane trailers. (No effort was made to separate cultivars for milling purposes because of logistics.) Cane in each plot was cut by deadheading the mechanical harvester and transport equipment. A random sample (100+ pounds) of cane was collected at the sugar mill each year for trash determination. It was recognized that individual cultivars would have different trash values, but we could not sample satisfactorily on an individual cultivar basis and chose to use a random trash sample.

Using loaded wagon weights and their tares, gross cane weight for each plot was determined. Gross cane weight from each plot and the plot area were used to calculate gross tons/acre of cane for each plot. Using the trash factor from the mill trash determination, net cane/acre was calculated for each plot. Brix and sucrose values from each sample were used to calculate the estimated yield of sugar in lb/net ton of 96° recoverable sugar using the Winter-Carp-Geerligs formula (Arceneaux, 1935). This value was used with the net cane yield to estimate yield 96° recoverable sugar per acre.

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[1] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by USDA or Okeelanta Corporation or an endorsement over other products not mentioned.

All data were analyzed using an analysis of variance with sample means tested for significant differences using Duncan's multiple range test (Steel and Torrie, 1960). Data were summarized and evaluations are based on the three-year means of the data because that is the amount of sugar that growers are paid for. These are also the figures that are needed to assist producers in making management decisions about which cultivars to plant.

RESULTS

Abnormal harvesting losses were not observed in the field after harvest. Two cultivars (CL 73-239 and CP 80-1743) had extreme rat damage in the plant-cane crop and each tended to have slightly higher field losses than cultivars without rat damage. Consequently, yields of cane are representative of cane which can be delivered by a combine harvester, which is the basis for a grower's payment. Since the objective of this test was to measure production under a combine harvesting system, no attempt was made to scrap plots for harvesting losses. Sugarcane rust (*Puccinia melanocephala*) severely infected CP 78-1247 as plant cane and moderately infected CP 72-1210 and CP 74-2005.

Table 1 summarizes cultivar production over the three-crop cycle. The highest yielding cultivars for tons of cane per acre were CP 80-1827, CP 73-1547, and CP 70-1133. These three cultivars are noted for vigor, disease resistance, and tonnage yield of cane. Further, these three cultivars along with CL 61-620 were the highest yielding cultivars in sugar per acre. The cultivars with the lowest yields (tonnage and sugar per acre) were CP 72-1210, CP 78-1247, and CP 78-2114. CP 78-2114 did not ratoon acceptably under the management system in this experiment.

Table 1. Performance of twelve cultivars of sugarcane over a three-crop cycle harvested mechanically at EREC, Belle Glade, Florida.+

	Cane Tonnage		96 Recoverable Sugar	
Cultivar	GTA(a)	NTA(b)	lb/NT	lb/acre
CP 80-1827	55.58 A	51.88 A	236.16 C	12197 A
CL 61-620	50.72 B	47.37 B	252.73 AB	12152 A
CP 70-1133	54.58 A	50.98 A	238.88 BC	12147 A
CP 73-1547	54.79 A	51.13 A	234.27 C	12003 A
CP 74-2005	44.92 C	41.91 C	260.04 A	10925 B
CP 72-2086	44.14 C	41.18 C	247.29 ABC	10275 BC
CP 70-1527	45.53 C	42.48 C	236.44 C	10019 BC
CL 73-239	40.83 D	38.07 D	253.78 AB	9706 C
CP 80-1743	40.14 D	37.34 D	248.10 ABC	9414 C
CP 72-1210	36.78 E	34.25 E	239.18 BC	8171 D
CP 78-1247	35.57 E	33.08 E	243.30 BC	8060 D
CP 78-2114	35.03 E	32.75 E	240.00 BC	7904 D

+ Each value represents the average of three replications over three crops. Mean values with different letter values are significantly different at the 10% level according to Duncan's multiple range test.

(a) Gross Tonnage/acre

(b) Net Tonnage/acre

Crusher juice quality parameters (Table 2) show that the high tonnage cultivars had slightly lower juice quality than other cultivars. Juice purity indicated that all cultivars had good maturity. The cultivars with the highest sugar/net ton were CP 74-2005, CL 73-239, CL 61-620, CP 80-1743, and CP 72-2086.

Table 2. Crusher juice characteristics of twelve cultivars of sugarcane over 3 years harvested mechanically at EREC, Belle Glade, Florida. +

Cultivar	Brix %	Sucrose %	Purity %
CP 80-1827	19.14 E	16.88 D	88.19 AB
CL 61-620	20.09 ABCD	17.87 ABC	88.92 AB
CP 70-1133	19.43 DE	17.17 BCD	88.38 AB
CP 73-1547	19.50 DE	17.13 BCD	87.81 AB
CP 74-2005	20.28 AB	18.35 A	90.56 A
CP 72-2086	20.18 ABC	17.80 ABC	88.16 AB
CP 70-1527	19.80 ABCDE	17.24 BCD	87.13 B
CL 73-239	20.35 A	17.99 AB	88.51 AB
CP 80-1743	20.29 AB	17.71 ABCD	87.28 B
CP 72-1210	19.54 CDE	17.37 BCD	88.90 AB
CP 78-1247	19.67 BCDE	17.61 ABCD	89.53 AB
CP 78-2114	19.26 E	17.02 CD	88.35 AB

+ Each value represents the average of three replications over three crops. Mean values with different letter values are significantly different at the 10% level according to Duncan's multiple range test.

Growth characteristics of the cultivars (Table 3) were diverse. CP 70-1527 was the most erect cultivar with CP 72-1210 and CP 80-1827 exhibiting acceptable erectness/machine adaptability across the three crop cycle. Cultivars with the lowest erectness ratings were CP 70-1133, CP 73-1547, CP 78-2114, CP 80-1743, and CL 73-239. Cultivars with an erectness rating over 3.0 are capable of being mechanically harvested by the Austoft 7700 without significant feeding problems or travel speed reductions.

One of the requirements for cultivars adapted to mechanical harvesting is sufficient vigor to insure stool survival after harvesting. Visual rating of the root anchoring system (Table 3) before the second-ratoon crop harvest caused us to believe that cultivars differed in this characteristic. However, the rating system utilized was not sufficiently sensitive to detect significant statistical differences. It should be noted that the two cultivars (CP 80-1827 and CP 80-1743) with the highest third-ratoon crop growth ratings had high root system ratings, but diverse erectness ratings. Growth ratings (potential cane yield) of the ratooning cane (Table 3) averaged for three

Table 3. Cultivar growth characteristics of twelve cultivars harvested mechanically at EREC, Belle Glade, Florida.+

Cultivar	Three Crop Erectness[1/]	Second Ratoon Root System[2/]	Three Crop Growth[3/]
CP 80-1827	7.06 B	4.0	4.06 A
CL 61-620	4.11 DE	3.7	3.18 CDE
CP 70-1133	2.72 G	3.7	3.39 CD
CP 73-1547	2.78 G	3.3	3.78 AB
CP 74-2005	4.89 C	3.3	3.46 BC
CP 72-2086	3.56 EF	3.3	3.04 DE
CP 70-1527	8.39 A	4.0	3.37 ABC
CL 73-239	3.17 FG	3.0	3.28 CD
CP 80-1743	3.06 FG	4.0	3.29 CD
CP 72-1210	7.50 B	4.0	2.82 EF
CP 78-1247	4.50 CD	3.3	2.58 EF
CP 78-2114	2.72 G	3.7	2.58 F
			NS

+ Each value represents the average of three replications over three crops. Mean values with different letter values are significantly different at the 10% level according to Duncan's multiple range test.

[1/] 1 - 10 Scale, 1 = erect, 10 = recumbent.

[2/] 1 - 4 Scale, 1 = uprooted, 4 = root system well anchored.

[3/] 1 - 5 Scale, rating equal to estimated tonnage per acre/10.

harvests showed CP 80-1827 and CP 73-1547 with the highest expected yields. The lowest growth ratings occurred with CP 78-2114, CP 72-1210, and CP 78-1247.

Growth ratings after the second-ratoon harvest (Table 4) showed CP 80-1827 was superior to all other cultivars. These growth ratings were supported by stand counts of the third-ratoon crop (Table 4). Other cultivars with acceptable stands in some plots included CP 80-1743, CP 74-2005, and CL 73-239. The remaining cultivars did not have sufficient stands to produce acceptable yields in third ratoon. As a result, the experiment was terminated after evaluating these ratings.

Table 4. Cultivar regrowth characteristics of twelve cultivars as third ratoon after three years of mechanical harvest at EREC, Belle Glade, Florida.+

Cultivar	Third Ratoon Growth [1]	Third Ratoon Stalk Counts/foot
CP 80-1827	2.90 A	6.57 A
CL 61-620	1.60 CD	4.63 ABC
CP 70-1133	2.07 BC	4.33 ABCD
CP 73-1547	1.60 CD	4.70 ABC
CP 74-2005	2.20 B	4.85 ABC
CP 72-2086	1.87 BCD	4.39 ABCD
CP 70-1527	2.17 B	3.22 BCD
CL 73-239	2.17 B	5.61 AB
CP 80-1743	2.20 B	5.31 ABC
CP 72-1210	1.53 D	2.74 CD
CP 78-1247	1.83 BCD	2.65 CD
CP 78-2114	1.43 D	1.82 D

+ Each value represents the average of three replications. Mean values with different letter values are significantly different at the 10% level according to Duncan's multiple range test.

[1] Estimated tonnage yield/acre divided by 10.

Yields of sugar/acre in the plant cane crop are shown in Table 5. Better performing cultivars were CL 61-620, CP 70-1133, and CP 73-1547. CP 78-1247 and CP 72-1210 had the lowest yield of sugar/acre. A concern of producers is the decrease in yield of sugar/acre exhibited by the second-ratoon crop compared to plant-cane crop. Table 5 shows the percent yield of sugar/acre of the second-ratoon crop compared to the plant crop. Two cultivars (CP 80-1743 and CP 78-1247) essentially maintained yield of sugar/acre. However, the plant-crop yields of these two cultivars were lower than normal because of severe rat damage in CP 80-1743 and sugarcane rust in CP 78-1247.

DISCUSSION

Cultivars with high vigor produced the most sugar/acre over the three crop cycle. Satisfactory cultivar performances with mechanical harvesting after three crops on organic soil appears related to sufficient vigor to overcome damage caused by mechanical harvesting and transport equipment. Cultivar growth characteristics did not interfere with mechanical harvesting in these plots. Growers should recognize that the root system of a sugarcane cultivar will affect its long term performance on organic soil when subjected to mechanical harvesting.

Table 5. Percent reduction of sugar/acre between second ratoon and plant cane harvested mechanically at EREC, Belle Glade, Florida.+

Cultivar	Plant Cane Yield 1b sugar/acre	2nd Ratoon 1b sugar/acre % plant cane
CP 80-1827	14852 BC	73.3 BC
CL 61-620	16897 A	55.3 DE
CP 70-1133	16086 AB	64.3 CDE
CP 73-1547	15127 ABC	66.3 CDE
CP 74-2005	14250 BCD	66.3 CDE
CP 72-2086	13494 CDE	67.3 CDE
CP 70-1527	11686 EF	77.3 BC
CL 73-239	12414 DEF	70.0 BCD
CP 80-1743	10561 FG	105.3 A
CP 72-1210	9325 GH	83.7 B
CP 78-1247	8254 H	98.3 A
CP 78-2114	11686 DEF	51.7 E

+ Each value represents the average of three replications. Mean values with different letter values are significantly different at the 10% level according to Duncan's multiple range test.

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PREEMERGENCE CONTROL OF ITCHGRASS (*(ROTTBOELLIA COCHINCHINENSIS)* IN SUGARCANE[1]

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ABSTRACT

Itchgrass has become a serious weed problem in Louisiana sugarcane. Soil-incorporated trifluralin is the standard preemergence treatment for control of itchgrass, but grower concerns over the potential yield reduction associated with its mechanical incorporation has stimulated interest in alternative preemergence soil-surface applied herbicides. Itchgrass control and sugarcane injury with both soil-incorporated and surface applied preemergence herbicides were compared at several locations in the sugarcane growing regions of Louisiana. Itchgrass control with pendimethalin, fomesafen, and clomazone applied in the spring to unshaved sugarcane beds was comparable to that of soil-incorporated trifluralin. In other studies, soil-surface applications of pendimethalin plus atrazine (2.2 and 3.4 plus 3.3 kg/ha), prodiamine (1.7 to 2.8 kg/ha), clomazone (1.1 to 2.2 kg/ha), and fomesafen (0.8 and 1.1 kg/ha) provided acceptable (>80%) itchgrass control when compared to the untreated check. Fomesafen (0.6 kg/ha), quinchlorac (0.3 to 1.1 kg/ha), terbacil (2.1 kg/ha), metribuzin (2.6 kg/ha), and atrazine (3.3 kg/ha) provided poor itchgrass control. Sugarcane injury was minimal with the exception of clomazone, which caused a temporary bleaching of sugarcane foliage at only one location. Sugarcane stalk populations following treatment with quinchlorac, terbacil, metribuzin, and atrazine were comparable to the untreated check and were reflective of poor early-season itchgrass control. Compared with soil-incorporated trifluralin, use of pendimethalin, prodiamine, fomesafen, and clomazone applied to the soil surface would reduce trips across the field and may minimize sugarcane injury, but may not provide consistent itchgrass control when rainfall is not received for activation. Nomenclature: Atrazine, 6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine; clomazone, 2-[(2-chlorophenyl)methyl]-4,4-dimethyl-3-isoxazolidinone; fomesafen, 5-[2-chloro-4-(trifluoromethyl)phenoxy]-N-(methylsulfonyl)-2-nitrobenzamide; metribuzin, 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one; pendimethalin, N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine; prodiamine, 2,4-dinitro-N,N-dipropyl-6-(trifluoromethyl)-1,3-benzenediamine; quinchlorac, 3,7-dichloro-8-quinoline-carboxylic acid; terbacil, 5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4-(1H,3H)-pyrimidinedione; trifluralin, 2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine].

INTRODUCTION

Itchgrass [*Rottboellia cochinchinensis* (Lour.) Clayton] was introduced into southern Louisiana in the 1920's (4) and has become a serious weed problem in sugarcane (*Saccharum* sp.), corn (*Zea mays* L.), and soybeans [*Glycine max* (L.) Merr.]. Itchgrass is an aggressive, erect annual grass that may grow to 3 m tall (1). Germination in late-season, prolific seed production, and ability to persist under a crop canopy, contribute to making itchgrass a potential major weed problem in many cropping systems (8). Lencse and Griffin (2) reported a 34, 42, and 43% reduction in sugarcane stalk production, and cane and sugar yields, respectively, when itchgrass was allowed to compete with sugarcane in early-season prior to layby.

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In Louisiana, itchgrass in sugarcane is controlled with a soil-incorporated treatment of trifluralin in the spring followed by asulam [methyl[(4-aminophenyl)sulfonyl]carbamate] early postemergence if needed (7). To facilitate trifluralin incorporation, the top of the bed is removed in a shaving operation and the soil above the sugarcane is loosened with one pass of a rolling cultivator. The herbicide is applied on a band on top of the bed and incorporated with two additional passes of a rolling cultivator. At the layby (last) cultivation, trifluralin is reapplied as a broadcast spray directed below the crop canopy and incorporated with rolling bed choppers.

Pendimethalin applied preemergence to the soil surface at rates of 3.3 to 4.5 kg/ha has provided good itchgrass control with no adverse effect on sugarcane yield (5). Weed control with pendimethalin was most effective when rainfall of at least 1.25 cm was received within 10 days after treatment. In other studies, itchgrass control was at least 80% with pendimethalin at 3.4 kg/ha and prodiamine at 2.2 to 3.4 kg/ha (7). Fomesafen at 0.6 kg/ha and clomazone at 2.2 kg/ha gave 60 to 75% control. Soil-incorporated treatments of terbacil, at 3.6 kg/ha and trifluralin at 2.2 kg/ha provided about 60 days of itchgrass control (3). Trifluralin at 2.2 kg/ha followed by asulam at 3.7 kg/ha controlled 94% of itchgrass and was more consistent than either treatment applied alone (6).

Since growers are concerned about potential sugarcane yield reductions associated with the incorporation of trifluralin, soil-surface applications of herbicides currently registered in sugarcane along with others presently registered or near registration in other crops were evaluated for itchgrass control and sugarcane injury under similar conditions at several locations in the sugarcane growing regions of Louisiana.

MATERIALS AND METHODS

Trifluralin Comparison Studies

Studies were conducted at Rougon and Thibodaux, LA in 1988 and at Maringouin and Thibodaux, LA in 1989. The Rougon and Maringouin sites were located in the northern sugarcane growing region of Louisiana whereas the Thibodaux site was located in the southern growing area. The sugarcane cultivar 'CP 70-321' (plant cane) was present at Rougon in 1988, 'CP 70-321' (second stubble) was present at Thibodaux in 1988 and 1989, and 'CP 76-331' was present at Maringouin in 1989. Natural itchgrass infestations occurred at each location.

Treatments consisted of soil-incorporated trifluralin at 2.2 kg/ha and pendimethalin at 2.2 and 3.3 kg/ha, fomesafen at 0.84 kg/ha, and clomazone at 1.1 and 1.7 kg/ha applied directly to the soil surface. Plots to be treated with trifluralin were shaved (2.2 to 5 cm of soil removed) prior to application. Trifluralin was applied to a 90-cm band on top of the sugarcane bed and incorporated immediately after treatment with two passes of a rolling cultivator. Soil-surface treatments were applied as a 90-cm band over-the-top of the sugarcane. In 1988, herbicides were applied on April 20 at Rougon and on March 22 at Thibodaux, and in 1989 on March 15 at Maringouin and on March 14 at Thibodaux. At all locations sufficient rainfall to activate herbicides was received within 10 days after application. At the time of application, sugarcane was 64 to 76 cm, 10 to 15 cm, and 8 to 10 cm in height at Rougon, Maringouin, and Thibodaux (1989), respectively. Green cane growth was not present when herbicides were applied at the Thibodaux site in 1988 due to top-kill of emerged cane by frost. Itchgrass was not present at any of the sites when the herbicides were applied. Visual itchgrass control and sugarcane injury were rated just prior to the layby cultivation in mid-May.

A randomized complete block experimental design with 4 replications in 1988 and 5 replications in 1989 was used. Data were subjected to analysis of variance for individual locations. Differences among treatment means were determined using Fisher-protected Least Significant Difference (LSD) tests at the 5% level of probability.

Surface Applied Herbicide Studies

Field studies were conducted in 1989 in Iberia Parish near Loreauville, LA and in Assumption Parish near Labadieville, LA. The sugarcane variety CP 70-321 (first stubble) was planted at Loreauville while CP 72-370 (plant cane) was planted at Labadieville. At both locations, sugarcane was planted on raised beds spaced 1.8 m apart. Soil type at Loreauville was an Iberia silty clay (Vertic Haplaquoll) with a pH of 6.1 and organic matter of 1.4% and at Labadieville was a Commerce silt loam (Thermic Aeric Fluvaquent) with a pH of 6.0 and organic matter of 1.7%.

Herbicides and rates used were pendimethalin plus atrazine at 2.2 plus 3.3 and 3.4 plus 3.3 kg/ha, prodiamine at 1.7, 2.2, and 2.8 kg/ha, clomazone at 1.1, 1.7, and 2.2 kg/ha, fomesafen at 0.6, 0.8, and 1.1 kg/ha, quinchlorac at 0.3, 0.6, and 1.1 kg/ha, terbacil at 2.1 kg/ha, metribuzin at 2.6 kg/ha, and atrazine at 3.3 kg/ha. Herbicide treatments were applied on March 16 at Loreauville to a band on the sugarcane bed following removal of cane and weed residue with a rotary mower. Green cane growth approximately 5 cm tall was present after mowing. At Labadieville, the residue was not removed and herbicide treatments were applied to a band on the sugarcane bed on March 14 with green cane growth 15 to 25 cm tall. At both locations, itchgrass was not present at time of application.

Visual itchgrass control and crop injury ratings were made 33 and 61 days after treatment (DAT), respectively, at Loreauville and 28 and 70 DAT, respectively, at Labadieville. Sugarcane stalk height was determined in late September on 12 randomly-selected stalks by measuring from the soil surface to the youngest visible dewlap, a structure which is triangular in shape and present where the leaf blade and sheath join. Numbers of millable sugarcane stalks were determined for the entire plot in late September by counting all stalks with a height of at least 1.7 m.

A randomized complete block experimental design with five replications was used at both locations. Data were subjected to analysis of variance for individual locations and across locations. Differences among treatment means were determined using Fisher-protected Least Significant Difference (LSD) tests at the 5% level of probability.

Herbicide treatments for all studies were applied with a tractor-mounted compressed air sprayer delivering 190 l/ha at 210 kPa using a standard three nozzle arrangement with one nozzle directly over the row and one nozzle on each side of the row on 15 cm drops. This nozzle arrangement provided treatment of a 90 cm band, on top of the sugarcane row. Individual plots were 5.3 m wide (three sugarcane rows) by 12.2 m long at all locations.

RESULTS AND DISCUSSION

Trifluralin Comparison Studies

Itchgrass control with trifluralin ranged from 83% at Maringouin in 1989 to 98% at Rougon in 1988 and averaged 91% (Table 1). At both locations in 1988 and at Maringouin in 1989, itchgrass control with the soil-surface applied treatments of pendimethalin, fomesafen, and clomazone was similar to the trifluralin standard with the average level of control for the four studies ranging from 80 to 88%. Of the herbicides evaluated, clomazone appeared to be the most inconsistent with itchgrass control ranging from 75 to 95% at the highest rate evaluated. In fields with a heavy itchgrass infestation, control of less than 80% would not be sufficient and an early postemergence application of asulam would be advantageous (7). Temporary bleaching of the sugarcane foliage was noted with clomazone at all sites except at Thibodaux in 1988 where no green-cane growth was present at time of herbicide application (data not presented). Sugarcane recovery, however, was rapid. It appears that with clomazone, foliar absorption may be required to induce visible injury symptoms.

Table 1. Visual ratings of itchgrass control with herbicides applied preemergence soil-incorporated (PI) and preemergence soil-surface (PRE) in Thibodaux, Rougon, and Maringouin, LA.

			1988		1989	
Herbicide	Rate	Method of application	Thibodaux	Rougon	Thibodaux	Maringouin
	(kg/ha)		(%)			
Trifluralin	2.2	PI	88	98	96	83
Pendimethalin	2.2	PRE	88	89	91	84
	3.3	PRE	80	88	82	83
Fomesafen	0.84	PRE	88	93	81	81
Clomazone	1.1	PRE	69	95	75	74
	1.7	PRE	75	95	85	77
LSD (0.05)			NS	NS	19	NS

Surface Applied Herbicide Studies

These studies were conducted to compare only preemergence soil-surface applied treatments. A herbicide treatment x location interaction was significant for itchgrass control indicative of inconsistent herbicide performance. Consistent and acceptable (>80%) control, however, was observed with pendimethalin plus atrazine, prodiamine, clomazone, and fomesafen at 0.8 and 1.1 kg/ha (Table 2). Itchgrass control with the currently registered herbicides terbacil, metribuzin, and atrazine and with the unlabelled quinchlorac and fomesafen (0.6 kg/ha) treatments was not consistent and unacceptable (<80%) when averaged for the two locations.

A herbicide x location interaction was also significant for sugarcane injury. With the exception of clomazone, sugarcane injury at both locations was no more than 7% (Table 2). At Loreauville, sugarcane injury with clomazone was minimal, but ranged from 9 to 22% at Labadieville. Injury at Labadieville with clomazone consisted of bleaching or whitening of young leaves. CP 70-321, in the plant-cane year is less sensitive to preemergence herbicides than CP 72-370 (9). Sugarcane leaf injury has also been shown to increase with later postemergence herbicide applications of asulam with CP 70-321 exhibiting less leaf injury than CP 72-370 (10). At the Labadieville location, plant cane of CP 72-370 with several leaves emerged was present at the time of treatment.

Small differences in sugarcane stalk height among treatments was observed at both locations (Table 2). However, when compared to the untreated check, sugarcane height was not reduced by any herbicide treatment and when averaged across locations, significant differences were not obtained.

A herbicide x treatment interaction was not obtained for stalk populations. Averaged over locations, stalk populations for pendimethalin plus atrazine, prodiamine, clomazone, and fomesafen were greater than the untreated check (Table 2). Stalk populations following treatment with quinchlorac, terbacil, metribuzin, and atrazine were not significantly different from the untreated check.

The reduced stalk populations, were probably related to the unacceptable itchgrass control observed for these treatments (Table 2).

Table 2. Visual itchgrass control and sugarcane injury ratings, and sugarcane stalk height and millable stalk counts as influenced by herbicide application at Loreauville and Labadieville, LA, 1989.

		Itchgrass control		Sugarcane injury		Stalk height			Stalk population		
Herbicide	Rate	Loreauville	Labadieville	Loreauville	Labadieville	Loreauville	Labadieville	Avg	Loreauville	Labadieville	Avg
	(kg/ha)	(%)				(cm)			(no./ha x 10^3)		
Pendimethalin + atrazine	2.2 + 3.3	89	90	0	0	222	247	235	71.2	60.3	65.8
Pendimethalin + atrazine	3.4 + 3.3	93	93	0	1	226	247	237	75.7	59.7	67.7
Prodiamine	1.7	85	90	1	0	225	243	234	70.9	57.8	64.3
	2.2	85	83	0	2	222	248	235	70.0	58.0	64.0
	2.8	90	90	0	0	226	247	237	77.2	60.2	68.7
Clomazone	1.1	82	90	2	9	225	248	237	71.4	58.7	65.0
	1.7	87	92	2	12	227	250	239	72.9	64.8	68.9
	2.2	81	93	2	22	226	242	234	69.9	63.6	66.7
Fomesafen	0.6	72	84	0	2	221	252	237	67.8	60.9	64.4
	0.8	93	89	0	7	230	249	240	73.5	61.9	67.7
	1.1	86	81	0	3	224	250	237	66.9	56.7	61.8
Quinchlorac	0.3	42	4	0	4	221	248	235	58.9	54.8	56.9
	0.6	43	55	0	1	219	249	234	58.7	55.2	56.8
	1.1	43	58	0	5	217	248	233	61.4	56.0	58.7
Terbacil	2.1	70	65	1	7	224	240	232	66.8	52.4	59.6
Metribuzin	2.6	51	85	1	5	225	244	235	62.2	56.2	59.4
Atrazine	3.3	39	81	0	4	220	245	232	57.7	54.9	56.3
Untreated	...	0	0	0	0	220	247	233	50.2	53.4	51.8
LSD (0.05)		19	20	2	4	7	7	NS	9.8	NS	8.0
Pr > F		<0.01	<0.01	0.03	<0.01	0.03	0.05	0.10	<0.01	0.38	<0.01

CONCLUSIONS

Preemergence treatments of pendimethalin, prodiamine, fomesafen, and clomazone applied to the soil surface generally provided itchgrass control comparable to a standard soil-incorporated application of trifluralin. Use of the soil-surface applied herbicides would offer cost savings through reduction in trips across the field and may minimize the sugarcane injury associated with the shaving and incorporation operations required when trifluralin is used. It should be noted that trifluralin provided excellent and consistent itchgrass control regardless of location or year. Mechanically incorporated trifluralin, unlike the surface applied herbicides, would not be dependent on rainfall for activation.

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POSTEMERGENCE BERMUDAGRASS (*CYNODON DACTYLON*) CONTROL IN SUGARCANE (*SACCHARUM* SP.) WITH DALAPON

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ABSTRACT

Dalapon has been the standard postemergence herbicide treatment for the control of bermudagrass in Louisiana sugarcane fields since 1955. Field and greenhouse studies were conducted between 1983 and 1987 to reevaluate the effectiveness of dalapon in controlling this weed in currently-planted sugarcane cultivars. Dalapon containing a mixture of the sodium (72.5%) and magnesium (12%) salts was post-directed to the base of the sugarcane but over-the-top of bermudagrass. Bermudagrass control following the application of dalapon at 5.2 kg ai/ha ranged from 7 to 77%. Some sugarcane injury was observed following dalapon treatment. There was some indication that the level of bermudagrass control with dalapon was enhanced by the inclusion of asulam at 3.7 kg/ha, but control was not enhanced by the inclusion of MBR-22359, TCA, and 0.1M potassium phosphate (KH_2PO_4) in the treatment solution. The increased efficacy with asulam was generally accompanied by an increase in crop phytotoxicity. A crop-oil concentrate at 0.5% by volume in the treatment solution was more effective than 0.25% by volume in one field study. The results suggest that yield responses to the use of dalapon in currently planted sugarcane cultivars may be dependent on the sensitivity of the sugarcane cultivar and the response of bermudagrass to dalapon which may vary by location. Nomenclature: Sugarcane (*Saccharum* interspecific hybrids); bermudagrass [*Cynodon dactylon* (L.) Pers.]; dalapon, 2,2-dichloropropionic acid; asulam, methyl [(4-aminophenyl) sulfonyl] carbamate; TCA, trichloroacetic acid.

Additional index words

Asulam, MBR-22359, potassium phosphate, herbicide selectivity.

INTRODUCTION

Bermudagrass has been recognized as a problem weed of sugarcane in Louisiana since the early 1950's (14,15). Several factors may be contributing to increases in the number of sugarcane fields infested with bermudagrass. Tillage practices have changed, the top 2 to 5 cm of the row-top are no longer removed in the early spring with a shaving operation. The size of sugarcane farms has increased; the increase in farm size means longer intervals between cultivation in planted fields and disking and/or plowing of fallowed fields. Planting widths have increased; as a result, less soil is placed on top of the row to cover the low-growing bermudagrass during the layby cultivation. With the decrease in cultivation frequency has come an increased dependency on chemical weed control programs. These herbicides are effective for the control of johnsongrass [*Sorghum halepense* (L.) Pers.], itchgrass (*Rottboellia cochinchinensis*), and other tall-growing weeds; they are generally ineffective in controlling bermudagrass. As a result, weed-weed competition is reduced and more sunlight is received by the lower growing bermudagrass. Finally, the perimeters of the fields (ditchbanks and headlands) are usually mowed or treated with herbicides which promote the establishment of a bermudagrass sod. Once established on the ditchbank and headland, the bermudagrass tends to spread into the field.

In 1955, dalapon was labelled for the postemergence control of bermudagrass in sugarcane (14). Sequential applications of dalapon at broadcast rates of 5.2 kg/ha are generally required to control bermudagrass in sugarcane (14). To be effective, dalapon should be applied to actively growing bermudagrass. An initial application is usually made in early-April with a follow-up application being made in mid-May. Applications after mid-May can result in significant sugarcane injury (9).

Dalapon's control of bermudagrass in sugarcane and other agronomic crops throughout the lower Mississippi Valley region has been inconsistent. Soil moisture (3), relative humidity (7,12) and differences in bermudagrass biotypes (1) have been used to explain this inconsistency. The addition of surfactant and potassium phosphate (KH_2PO_4) has overcome some of the environmental causes of these inconsistences (4). In some cases, bermudagrass control in sugarcane has been improved by the use of mixtures of dalapon with other postemergence herbicides such as a three-way mixture of TCA + dalapon + 2,4-D [(2,4-dichlorophenoxyl) acetic acid] at 7.8 + 2.2 + 1.1 kg/ha (15). Mixing dalapon with asulam at 5.0 + 3.7 kg/ha has resulted in increased johnsongrass control in sugarcane (10). The latter mixture has not been evaluated for the control of bermudagrass. The experimental herbicide MBR-22359 provided selective preemergence and postemergence control of perennial johnsongrass in several crops including corn (5). It has controlled bermudagrass in cotton when applied preemergence (2).

Some sugarcane cultivars currently grown in Louisiana may be injured by postemergence applications of dalapon made in late-April (11). This injury can be of sufficient magnitude to nullify potential yield increases associated with bermudagrass control. Cane injury following an application of dalapon at this time of year may inhibit tillering which in turn reduces the population of harvestable stalks and gross cane yields (14). The plant-cane crop is particularly vulnerable to this type of injury (13,15).

This study was initiated to evaluate the response of currently-planted sugarcane cultivars and bermudagrass to postemergence applications of dalapon as affected by sequential applications, herbicide mixes, and additives.

MATERIALS AND METHODS

Practices common to field studies

Ratoon fields heavily (> 80% of the row top) infested with bermudagrass were selected for this study. In each field, the sides of the 1.8 m wide sugarcane beds were off-bared and reformed in mid-March with rolling disk cultivators to remove weed growth and crop residue from the previous harvest. A mixture of dicamba (3,6-dichloro- 2-methoxybenzoic acid), at 0.3 kg/ha, 2,4-D] at 0.8 kg/ha, and either terbacil [5-chloro-3-(1,1-dimethylethyl)-6- methyl 2,4(1*H*,3*H*)-pyrimidinedione] at 2.1 kg/ha [studies conducted at Magnolia Plantation (MAG)] or metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4- triazin-5(4*H*)-one] at 2.6 kg/ha [studies conducted at Little Texas Plantation (LTX)] was applied to a 90-cm band, on the row top, in late-March. This mixture provided postemergence control of a complex of broadleaf winter weeds and preemergence control of warm-season annual weeds including seedling johnsongrass. The treatment had little effect on bermudagrass. The untreated-row sides were cultivated at 2- to 3-week intervals until the layby (last) cultivation which was performed during late-May or early-June depending on the size of the crop. No layby cultivation was performed until at least 7 days after the final postemergence treatment. Soil, 3 to 5 cm deep, was deposited on top of the sugarcane row for the first time with this cultivation. In many cases, the soil partially covered the bermudagrass growing on top of the row.

Field experiments were arranged in a randomized complete block design. Individual plots consisted of three adjacent 1.8-m wide sugarcane rows. Significant differences were determined at the 0.05 level of probability.

Postemergence herbicide treatments were directed to the base (lower 15 cm) of the sugarcane shoots and over-the-top of the bermudagrass. Treatments were applied with a tractor-mounted, roller-pump pressurized sprayer. The spray boom contained two flat-fan nozzles mounted 30 cm to either side of row center on 30 cm long drop pipes. The nozzles were angled inward with each nozzle wetting 60 cm of the 90-cm band.

Visual estimates of sugarcane injury (leaf discoloration, stunting, chlorosis) and bermudagrass control (percentage of the row infested) were made at various intervals after treatment. Ratings were based on a scale of 0 to 100% with 0% representing no sugarcane injury or bermudagrass infestation levels on the beds equivalent to an untreated check and 100% representing kill of sugarcane or bermudagrass (no bermudagrass on the row). Counts of harvestable sugarcane stalks and stalk height measurements were made in mid- to late-August. A stalk whose youngest visible dewlap was at least 1.2 m above the soil surface was considered to be harvestable. The dewlap is defined as a triangular-shaped hinge in the collar region of the leaf where the leaf blade and sheath are joined. The youngest leaf containing a visible dewlap is located in the top of the stalk just below the whorl. Stalk height measurements were made on 12 stalks (4/row) in each plot from the soil surface to the youngest visible dewlap.

Sugarcane stalks were mechanically harvested and piled, burned to remove the majority of the leaf material, and weighed to determine gross cane yields. Fifteen harvested stalks were randomly selected from each plot, weighed to determine stalk weight, and crushed to extract the juice. The juice was analyzed for Brix by hydrometer and the content of sugar (sucrose) by polarimetry using standard methods (8). Theoretically recoverable sugar yields were calculated by methods described previously (6).

Field evaluation of herbicide mixtures (Study A)

Studies were conducted in 1983 on a second-ratoon field of sugarcane, cultivar CP 70-330, located at MAG near Schriever, Louisiana. Experimental treatments were applied on May 9, in an aqueous carrier volume of 374 L/ha. At the time of treatment bermudagrass was actively growing and was 10 to 15 cm tall and sugarcane was 68 cm tall with six fully expanded leaves.

Each treatment was replicated five times with individual plots being 15.2 m long. Sugarcane was harvested on October 10. Visual ratings of sugarcane injury and bermudagrass control, made 8 weeks after treatment, were subjected to arc sin transformations prior to analysis. The remaining data were transformed using $\log_{10}$. Transformations did not reduce the coefficients of variability appreciably suggesting that all assumptions for an ANOVA were being met. Therefore, actual data means were subjected to an analysis of variance. Means were separated using Fisher's Protected Least Significant Difference Test.

Field evaluation of herbicide mixtures at LTX and MAG (Study B)

Studies were conducted in 1984 on first-ratoon fields of sugarcane, cultivars CP 65-357 and CP 70-321, at LTX and MAG, respectively. The LTX site is located at Napoleonville, Louisiana. Treatment solutions were applied on April 24 (LTX) and April 25 (MAG) with follow-up applications of dalapon being applied on May 30 at both locations. At the time of the initial treatment, sugarcane averaged 51 cm tall with five leaves (cultivar CP 65-357) and 58 cm tall with five leaves (cultivar CP 70-321) at LTX and MAG, respectively. Bermudagrass at both locations was at least 10 cm tall.

Visual estimates of bermudagrass control and crop injury were made in mid- to late-August (August 14 to 27). Sugarcane was harvested on November 5 (LTX) and November 7 (MAG). Each treatment was replicated six times with individual plots being 13.1 (LTX) or 15.2 (MAG) m long. Data from the experiments were subjected to analysis of variance individually because of differences in treatment numbers. Differences between means were separated using Fisher's Protected Least Significant Difference Test.

Field evaluation of herbicide mixtures (Study C)

Studies were conducted on plant-cane (1985) and first-ratoon (1986) crops of sugarcane, cultivar CP 65-357 at LTX. Treatment solutions were applied on May 9, 1985, and April 25, 1986, over-the-top of bermudagrass as a 90-cm band at 187 L/ha. Follow-up applications of dalapon were made 4 (1985) or 5 (1986) weeks after the initial application of dalapon. All treatment solutions contained crop-oil concentrate (COC)[1] at 1% by volume. At the time of treatment, sugarcane averaged 132 cm (six fully-expanded leaves) and 94 cm (four fully-expanded leaves), in 1985 and 1986, respectively. Visual ratings of bermudagrass control and sugarcane injury were made 4 weeks after the final application of a treatment. Sugarcane was harvested on December 15, 1985, and December 5, 1986.

Treatments were replicated four (1985) or five (1986) times with individual plots being 13.7 m (1985) or 15.2 m (1986) long. Data from the two experiments were combined and subjected to an analysis of variance. Means were separated using the Least Square Means Test because of the unequal number of replications in the two experiments (16).

Additive Effects - Greenhouse

In early-January, a commercial bulb planter was used to remove 8-cm long cylindrical plugs of soil with a surface area of 25 cm^2 from a sugarcane ditchbank. These plugs contained winter-killed foliage, rooted bermudagrass stolons, and some rhizomes. The plugs were placed into 10 cm by 10 cm square plastic pots, filled with soil, and placed in the greenhouse for 8 weeks to allow the bermudagrass to become established. Plants were grown under a 12-h photoperiod supplemented with fluorescent lighting. Bermudagrass top growth was clipped every 2 weeks to promote uniform development. Plants were fertilized weekly throughout the study with a commercially-available soluble fertilizer.

Two weeks after the last clipping, bermudagrass was treated with dalapon ± additives as over-the-top postemergence sprays at 187 L/ha. Additives included COC at 0, 0.25, 0.5, and 1% by volume ± 0.1 M potassium phosphate (KH_2PO_4). The top growth of treated plants was clipped 2, 4, 8, and 24 h after treatment (HAT) and weighed. Bermudagrass was allowed to redevelop in the greenhouse for 4 weeks at which time top growth was removed and weighed.

The experiment was arranged in a randomized complete block. The experiment was repeated over time with each treatment being replicated four (1986) or five (1987) times. Fresh weight data from the two experiments were combined and subjected to a four (concentrations of COC) by two ($\pm KH_2PO_4$) by four (time of clipping) factorial analysis. Means were separated using Least Square Means Tests because of the unequal number of replications in the two studies (16).

Additive effects - Field

Field studies were conducted on plant-cane (1985) and first-ratoon (1986) crops of sugarcane, cultivar CP 65-357, at LTX on sites within the same fields used for Study C. Treatment solutions containing dalapon at 5.2 kg/ha with various concentrations of crop-oil concentrate (COC) ± 0.1 M KH_2PO_4 were applied on May 9, 1985, and April 25, 1986, over-the-top of bermudagrass as a 90-cm band at 187 L/ha. At the time of treatment, the plant-cane crop averaged 132 cm tall with 6 fully expanded leaves per shoot and the first-ratoon sugarcane averaged 98 cm tall with 4 fully expanded leaves per shoot. Bermudagrass covered 60% (6 cm tall) in 1985 and 80% (13 cm tall) in 1986 of the row at the time of treatment. Visual ratings of bermudagrass control and sugarcane injury were made 2 and 4 WAT. Sugarcane was harvested on December 15, 1985, and December 5, 1986.

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[1] Agridex, containing 83% parraffinic mineral oil and 17% polyoxyethylene sorbitan fatty acid ester, marketed by Helena Chemical Co., 5100 Poplar Ave., Memphis, TN 38137. The use of trade names in this publication does not constitute a guarantee, warranty, or endorsement of the product by the U.S. Dep. of Agric.

Each treatment was replicated four (1985) or five (1986) times with individual plots being 13.7 (1985) or 15.2 m (1986) long. Data from the two experiments were combined and subjected to a four (concentration of COC) by two ($\pm KH_2PO_4$) factorial analysis. Means were separated using Least Square Means Test because of the unequal number of replications in the two studies (16).

RESULTS AND DISCUSSION

Evaluation of herbicide mixtures with dalapon

In Study A, control of bermudagrass 8 weeks after treatment (WAT) was 52% and 63% by a single application of dalapon at 5.2 and 5.7 kg/ha, respectively (Table 1). Dalapon applied at 5.2 and 5.7 kg/ha in mixture with asulam increased bermudagrass control to 74 and 81%, respectively. The experimental herbicide MBR-22359 was relatively ineffective for postemergence control of actively growing bermudagrass at the 2.2 kg/ha rate. Combining MBR-22359 with dalapon resulted in bermudagrass control which was significantly lower than where dalapon was applied alone. Visual sugarcane injury, primarily stunting, was observed 8 WAT in plots treated with dalapon alone or in tank-mixture.

At the relatively high bermudagrass infestation levels encountered in this study, some reduction in sugarcane stalk numbers probably resulted from the competition, because stalk numbers were higher in the treated plots despite the early-season crop injury. Stalk numbers among the dalapon-treated plots were similar with only the stalk numbers following the dalapon + asulam mixture at the 5.7 + 3.7 kg/ha rate being significantly higher than the untreated-check. MBR-22359 did not control bermudagrass, yet stalk numbers were significantly higher than the untreated-check.

The early stunting of sugarcane shoots observed following the use of dalapon was not detected in August. Stalk heights following the use of dalapon were generally equivalent to the untreated-check. Differences in the weight of the harvested stalks and the sugar content of the extracted juice were not detected (data not presented).

Gross cane and sugar yields were increased an average of 12% over the untreated-check where dalapon was applied alone at 5.2 kg/ha. However, gross cane and sugar yields were not increased when dalapon was applied alone at 5.7 kg/ha. The yield reduction reflected the early season crop injury and the reductions in sugarcane stalk number and height. Bermudagrass control was improved with the addition of asulam to the spray mix as has been reported for johnsongrass (10). The yield responses with the dalapon + asulam mixtures appeared to be influenced by the rate of dalapon in the mixture. Dalapon at 5.2 kg/ha in the mixture gave gross cane and sugar yields that were lower than that for the same rate of dalapon applied alone whereas dalapon at 5.7 kg/ha in the mixture gave gross cane and sugar yields that were higher than that for the same rate of dalapon applied alone. MBR-22359 caused a slight increase in gross cane and sugar yields despite the poor bermudagrass control.

Asulam and TCA applied alone in Study B provided little (<30%) bermudagrass control 2 WAT (Table 2). However, a mixture of the two herbicides increased bermudagrass control to 50% at the MAG location only. Although unacceptable, the level of bermudagrass control observed with the mixture continued to be higher than either herbicide applied alive. The highest level of bermudagrass control observed 21 WAT at LTX (51%) or MAG (69%) occurred in plots receiving applications of dalapon. The control resulting from the various dalapon mixtures was similar to that observed with the standard 5.2 kg/ha rate of dalapon applied alone.

Table 1. Effect of dalapon and dalapon mixtures on bermudagrass (BG) control and sugarcane (CP 70-330) growth and yield. Study A.[a]

Treatment	Rate(s)	BG control	Crop injury	Stalk no.	Stalk ht.	Yield cane	Yield sugar
	(kg/ha)	----(%)----		(no./ha) x 10^3	(cm)	(kg/ha) x 10^3	(kg/ha) x 10^2
Dalapon	5.2	52	9	79.4	229	69.7	76.0
Dalapon + asulam	5.2 + 3.7	74	15	73.8	225	63.8	66.6
Dalapon	5.7	63	16	76.3	226	64.3	69.7
Dalapon + asulam	5.7 + 3.7	81	12	84.3	231	69.2	74.4
MBR-22359	2.2	8	3	82.4	230	68.3	76.5
Dalapon + MBR-22359	5.2 + 2.2	10	6	77.5	233	67.6	73.4
Untreated check	---	--	--	70.1	228	62.5	67.3
LSD (0.05)		13	5	9.3	4	4.6	5.2

[a] Visual estimates of bermudagrass control and crop injury were made 8 weeks after treatment. At the time of rating bermudagrass covered 93% of the raised bed's surface in the untreated-check.

A slight degree (< 10%) of sugarcane injury in the form of leaf necrosis was observed 2 WAT at both locations following dalapon treatment (data not presented). By the 21 WAT rating period, no sugarcane injury was visible. Differences among treatments in sugarcane stalk numbers and height at both locations and net cane yield at LTX were not detected (Table 2). Sugarcane yields were increased significantly (24%) over the untreated-check with a sequential application of dalapon at MAG. As in Study A, sugarcane yields did not increase with a mixture of asulam and dalapon. TCA in mixtures did not appear to enhance the activity of either dalapon or asulam.

In Study C, a mixture of asulam and dalapon did not increase bermudagrass control over that observed with dalapon alone which gave 66% control (Table 3). Some sugarcane injury was observed following dalapon application. This injury was primarily manifested as a reduction in the weight of harvested stalks and not as reductions in either stalk numbers or stalk height. As a result, gross cane and sugar yields following dalapon treatment were not significantly increased when compared to the untreated-check.

Additive effects - Greenhouse

The fresh weight ratio of bermudagrass regrowth to the weight of the top-growth at the designated clip-times was used as an indication of the efficacy of the various dalapon treatments 2because the initial amount of bermudagrass biomass (above- and below-ground) in the plugs was not constant. Significant interactions involving COC concentration, KH_2PO_4, and clipping the bermudagrass

Table 2. Effects of various postemergence herbicides on the control of bermudagrass and on the growth and yield of sugarcane at Little Texas (LTX) and Magnolia (MAG) Plantations. Study B.

		BG control[a]				Stalk					
		2 WAT		21 WAT		no.		ht.		Cane yield	
Herbicide(s)[b]	Rate(s)	LTX	MAG	LTX	MAG	LTX	MAG	LTX	MAG	LTX	MAG
	(kg/ha)	----------(%)---------				(no./ha) x 10^3		- (cm) -		(kg/ha) x 10^3	
Untreated check	---	--	--	--	--	37.9	51.4	132	142	30.9	45.2
Dalapon	5.2	36	40	7	31	48.1	54.1	137	140	35.6	44.8
Dalapon sequential	5.2 + 5.2	---	---	51	70	49.2	63.3	132	142	34.3	56.0
Dalapon + asulam	2.2 + 3.7	32	38	0	10	38.4	51.3	132	145	31.8	45.7
Dalapon + asulam	5.2 + 3.7	48	41	4	27	39.2	54.7	130	145	29.1	48.6
Dalapon + TCA	2.2 + 5.5	32	51	7	42	40.9	58.5	135	142	31.5	50.2
Asulam	3.7	22	13	1	6	38.1	56.1	135	145	30.0	50.4
TCA + asulam	2.7 + 3.7	32	28	0	11	41.5	56.0	135	145	32.7	47.5
TCA + asulam	5.5 + 3.7	22	50	2	31	40.1	52.2	132	147	32.5	45.9
TCA	5.5	26	26	0	5	39.1	52.0	132	142	28.7	42.8
TCA sequential	5.5 + 3.5	---	24	---	20	---	54.9	---	145	---	45.9
TCA	11.0	---	47	---	23	---	53.6	---	145	---	47.0
LSD (0.05)		11	17	10	20	NS	NS	NS	NS	NS	7.0

[a] Visual estimates of bermudagrass (BG) control were made 2 and 21 weeks after treatment (WAT).

[b] The latter two treatments (TCA sequential at 5.5 + 3.5 kg/ha and TCA alone at 11.0 kg/ha) were not applied at LTX because of space limitations.

top-growth at various times after treatment were not obtained for this parameter (F=0.74, P=0.6756). Interactions involving the concentration of COC and the inclusion of KH_2PO_4 and the concentration of COC and time of clipping were not significant with F values of 1.88 (P=0.1344) and 0.69 (P=0.7188), respectively. Likewise, the interaction involving the use of KH_2PO_4 and the time of clipping was also not significant (F=0.90, P=0.44). When averaged over the other variables, the response to the inclusion of COC (F=9.93, P=0.0001) and the time of clipping (F=76.32, P=0.0001) was highly significant. A similar response to KH_2PO_4 was not evident (F=1.64, P=0.2011). When combined across COC concentrations ±0.1 M KH_2PO_4, the fresh weight ratio at the designated clip-times was significantly reduced as the interval between clipping and treatment increased (Table 4). Delaying clipping to 24 h after treatment (HAT) reduced the ratio by 74% over the water-treated check. Inclusion of 0.1 M KH_2PO_4 in the treatment solution did not improve the level of bermudagrass control (data not presented). Inclusion of COC at 0.25% by volume in the treatment solution reduced the fresh weight ratio from 0.50 to 0.36. COC concentrations greater than 0.25% (by volume) did not further enhance absorption since further reductions in the ratio were not obtained. This would & indicate that the effect of the COC was to improve spray coverage and/or droplet retention.

Table 3. Effects of postemergence applications of dalapon ± asulam on the control of bermudagrass (BG) and on the growth and yield of sugarcane at Little Texas Plantation. Study C.[a]

Herbicide(s)[b]	Rate(s)	BG control	Crop injury	Stalk no.	Stalk ht.	Stalk wt.	Cane yield
	(kg/ha)	--------(%)-------		(no./ha) x 10^3	(cm)	(kg)	(kg/ha) x 10^3
Dalapon	5.2	66 a	12 a	76.3	179	1.10 b	78.1
Asulam	3.7	16 b	1 b	72.0	176	1.20 a	72.2
Dalapon + asulam	2.2 + 3.7	56 a	11 a	80.2	177	1.07 b	74.3
Dalapon sequential	5.2 + 5.2	52 a	10 a	73.6	176	1.14 ab	76.2
Untreated check	---	---	---	73.4	179	1.14 ab	73.0
P > F				0.16	0.97	0.04	0.2

[a] Means within a column followed by the same letter are not significantly different at the 0.05 level of probability according to the Least Square Means Test.

[b] All treatment solutions contained crop-oil concentrate at 1% by volume.

Additive effects - Field Studies

Interactions involving COC concentration and the inclusion to 0.1 M KH_2PO_4 in the treatment solution were not obtained for any of the parameters evaluated in field studies. The response of bermudagrass and sugarcane to the various dalapon solutions was not affected by 0.1M KH_2PO_4 (data not presented). However, as in greenhouse studies the inclusion of COC in the treatment solution significantly enhanced the level of bermudagrass control with dalapon. As the concentration of COC in the mixture increased, the level of bermudagrass injury observed 2 WAT increased (Table 5). At 4 WAT, bermudagrass control was greater than 60% when COC was included at concentrations of 0.5% by volume or higher. The level of bermudagrass control observed with dalapon was not increased by increasing the COC concentration above 0.5%.

Sugarcane injury following dalapon treatment was slight and insignificant 2 WAT. By 4 WAT, some injury was observed (leaf necrosis and stunting) particularly where dalapon was applied with COC at 1% (v/v). Despite the sugarcane injury and the difference in the level of bermudagrass control between the various concentrations of COC, differences in sugarcane stalk populations and heights were not observed at the various COC concentrations in the presence or absence of KH_2PO_4 (Table 5). Hence, gross cane and sugar yields were similar following all treatments. As in the previous field studies, gross cane yields in the dalapon-treated plots tended to be similar to those in the untreated-check where full-season bermudagrass competition occurred (Table 5).

Seven field experiments were conducted for this study. Of these, five were conducted at LTX and two at MAG. Only the studies at MAG showed a positive yield response to the use of dalapon to control bermudagrass. The reason for this is not clear. The cultivar CP 65-357 was present in the treated fields at LTX while CP 70-330 (study A) and a full sibling, CP 70-321 (study B), were present in the treated field at MAG. Of the cultivars, CP 65-357 has been shown to be less susceptible to dalapon injury than CP 70-321 (11). Therefore, more crop injury on CP 65-357 may not be a plausible explanation. The occurrence of different biotypes of bermudagrass has been reported (1). This may have had a bearing on this study.

Table 4 Ratio of bermudagrass biomass fresh weight 4 WAT to the fresh weight of the treated bermudagrass biomass clipped at designated times after treatment with dalapon mixes containing various concentrations of crop-oil concentrate (COC). Greenhouse.[a]

Clip time	COC concentration (%)[b]				Mean
	0.00	0.25	0.50	1.00	
(HAT)	----------(Ratio)----------				
2	0.70	0.63	0.56	0.56	0.61
4	0.61	0.39	0.45	0.43	0.47
8	0.43	0.23	0.26	0.23	0.29
24	0.27	0.19	0.15	0.14	0.19
Mean	0.50 A	0.36 B	0.36 B	0.34 B	

[a] Means for clipping treatments across COC and means for COC across clipping treatments followed by the same letter are not significantly different at the 0.05 level of probability as determined by the Least Square Means Test.

[b] Dalapon was included in all treatment solutions at 5.2 kg/ha. An untreated check, clipped 24 h after treatment (HAT) with a water spray produced 6.12 g of regrowth and a ratio of 0.85.

Table 5. Bermudagrass (BG) and sugarcane (SC) response to dalapon solutions containing various concentrations of crop-oil concentrate (COC) ± 0.1 M KH_2PO_4. Field.[a]

COC conc.[b]	BG control		SC injury	Stalk		Yield	
	2WAT	4WAT	4WAT	no.	ht.	cane	sugar
(% v/v)	---------(%)-----------			(no./ha) x 10^3	(cm)	(kg/ha) x 10^3	(kg/ha) x 10^2
0.00	20 c	39 c	11 b	73.3	173	73.9	94.8
0.25	31 b	55 b	10 b	75.0	174	75.2	96.2
0.50	32 ab	68 a	13 b	77.6	179	76.5	97.1
1.00	44 a	77 a	17 a	75.5	174	76.1	97.5
CV (%)	50	28	39	10	6	10	18
				NS	NS	NS	NS
Untreated check				73.6	179	74.3	93.3

[a] Means within a column followed by the same letter are not significantly different at the 0.05 level of probability according to the Least Square Means Test. Visual ratings were made 2 (BG control) and 4 (BG control and SC injury) weeks after treatment (WAT).

[b] All treatment solutions contained dalapon at 5.2 kg/ha.

Failure to show consistent yield reductions from bermudagrass competition in this study indicates that (1) yield reductions associated with bermudagrass competition are minimal, (2) dalapon injury to sugarcane is of sufficient magnitude to offset any yield reductions associated with bermudagrass competition, or (3) despite the fact that the bermudagrass topgrowth is necrotic 4 WAT with dalapon, the thatch may be able to continue to exert some suppression or alleleopathic response.

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REGENERATION AND PHENOTYPIC VARIABILITY OF PLANTS CULTURED *IN VITRO* FROM MATURE SUGARCANE CARYOPSES

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ABSTRACT

Laboratory and field studies were conducted to determine regeneration efficiency and phenotypic variability of subclones derived from *in vitro* culture of mature sugarcane caryopses. Selfed (S_1) caryopses of three varieties (CP 67-412, CP 72-355, and CP 81-311) were subjected to callus culture (Murashige and Skoog [MS] medium with 2,4-D) or shoot proliferation culture (MS medium with shoot proliferation hormones). Varieties differed in frequencies of non-shoot-forming friable and mucilaginous calli, but not in frequency of shoot-forming callus. Regeneration from callus averaged 5.7 (range 3 to 11) plants per germinated caryopsis across varieties.

Subclones from nine caryopses (lines) of CP 72-355 were examined for variability in the plant-cane crop. There was substantial variability among subclones within lines. Data for most subclones within lines fit a normal distribution for each parameter. Among lines, subclone variances were heterogeneous and appeared to vary randomly and independently about the mean. Empirical evidence suggested that variances were similar for plants regenerated by callus culture and shoot proliferation culture.

Results demonstrated that callus of mature caryopses can be regenerated to plants and that variety affected callusing response. Identification of agronomically useful subclone variants would be difficult because of sampling variation.

INTRODUCTION

Sugarcane was one of the first crop species to be studied using *in vitro* propagation (12). Various tissue culture techniques and explant sources have been used to produce disease-free seed cane, induce genetic (or phenotypic) change, conserve germplasm, and study basic biochemical and physiological processes (7,16). Frequently, apical meristem or immature leaf tissue is used as explant source; plants are subsequently differentiated from axillary buds, embryos, or direct organogenesis.

An important aspect of any culturing experiment is the variability induced in the population of regenerated plants. This variability may or may not be desired depending on the objectives of the study. Somaclonal variation in crop plants may be a useful source of genetic variation (6,12). Induced variability of marker and agronomic characters in sugarcane appears to be a function primarily of cultivar (8,10,17); however, culture duration (14); source of explant tissue (5,12) and culture procedure, i.e., meristem vs. callus culture (11,15) may also effect variation.

There is no report of plant regeneration from the culture of sugarcane seed *in vitro*, although seed of several other clonally (25) and sexually (1,24,26) propagated species have been tested. Regeneration from seed in these species typically occurs by somatic embryogenesis. The magnitude of subclone variation in seed-derived subclones of sugarcane has not been determined.

Objectives of this study were to determine regeneration efficiency and phenotypic variability among regenerants derived from *in vitro* culture of mature sugarcane caryopses.

MATERIALS AND METHODS

Callus Culture

Caryopses of three selfed (S_1) sugarcane varieties (CP 67-412, CP 72-355, and CP 81-311) were excised from subtending glumes under a dissecting microscope. Only plump, apparently sound caryopses were selected. Caryopses were surface sterilized in 95% ethanol (30 s), 75% commercial bleach containing two drops of Micro surfactant (Cole-Parmer, Chicago, IL 60648[1]) (10 min), and rinsed in sterile demineralized water (three 10-min rinses). For each cultivar, five caryopses were placed in each of 30 sterile Petri dishes (100 mm) on agar medium with MS (Murashige and Skoog, 19) salts and the following organic constituents: nicotinic acid and pyridoxine HCl (1.0 mg/L), thiamine HCl (10.0 mg/L), glycine (2.0 mg/L), myoinositol (100.0 mg/L), agar (8.75 g/L), sucrose (20 g/L), and 2,4-dichlorophenoxyacetic acid (2,4-D, 2.2 mg/L) for callus induction. Media with and without 2,4-D will be referred to as MSA and MS media, respectively.

Caryopses on MSA medium were maintained at 28°C under continuous subdued light (0.5 μmol photosynthetically active radiation [PAR]/m^2/s), and subcultured at two-week intervals. Data were recorded at 2-d intervals on germination for approximately 4 wk, then at two-week intervals for callus type (shoot-forming, friable with no shoots, or mucilaginous). Shoot-forming calli or callus sectors were transferred to a filter paper bridge in Magenta GA-7 culture vessels (7.6 x 7.6 x 10.2 cm) (Magenta Corp., Chicago, IL 60641) containing 20 ml of regeneration (MS1) medium (MS broth containing 0.1 mg/L gibberellic acid and 0.01 mg/L 3-indolebutyric acid) once shoots appeared. Vessels were maintained at 28°C under a 12-h photoperiod (55 to 75 μmol PAR/m^2/s). At 14 wk, all remaining calli were transferred to MS1 medium.

Tillers of regenerated plants 1 to 2 cm tall were separated and transferred to 20 ml of MS2 medium (MS broth containing 6-benzylaminopurine [0.2 mg/L] and kinetin [0.1 mg/L]), in GA-7 vessels for shoot proliferation (9). Vessels were placed on an orbital shaker at 40 revolutions per minute. Tillers 4 to 5 cm tall were further separated and transferred to MS4 medium (half-strength MS broth containing 45 g/L sucrose) for rooting. Once roots developed, plants were transplanted individually to vermiculite in greenhouse flats.

Shoot proliferation culture

Sixty caryopses of each variety were sterilized, placed on filter paper bridges in MS broth, and maintained under the environmental conditions described above for regenerating calli. Once caryopses germinated, five seedlings of each variety were placed on semi-solid MS2 medium. Cultures were maintained on MS2 medium for 6 to 8 wk for shoot proliferation. Plants were maintained, subcultured, rooted, separated, and transferred to greenhouse flats as described above for regenerating calli.

Field experiment

All regenerants from culture were planted to the field in spring 1989 to maintain the material. Regenerants of CP 72-355 were chosen for further study of phenotypic variability because seedlings of this variety responded well to callus culture (Table 1). The population of subclones derived from each seed of this variety was considered a line. Of the eleven callus-derived and four shoot proliferation lines available (one shoot proliferation line did not survive in culture), nine lines were selected based on numbers of subclones. Six of the nine lines were derived from callus and three from shoot proliferation. The subclones (20 to 150 subclones per line) were selected at random.

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[1] Mention of a trademark or proprietary product does not constitute an endorsement or warranty by the USDA, nor does it imply its approval to the exclusion of other products that may also be suitable.

Table 1. Frequencies of germination, callus type, and plant regeneration from 150 caryopses (seed) of each of three sugarcane varieties.

Variety	Seed weight†	Germination	Callus type				Rooted plants§	Plants per seed¶
			Shoot-forming	Friable no shoots	Mucilaginous	Dead‡		
	(mg)	no.	% germination				no.	
CP 72-355	49.5	96 a#	21 a	64 b	9 a	6	1,101	11.4
CP 67-412	48.9	66 b	23 a	64 b	0 b	13	176	2.7
CP 81-311	32.1	85 a	13 a	78 a	4 b	5	247	2.9
Mean	43.5	82	19	68	5	8	508	5.7

† Weight of 150 caryopses.

‡ Caryopses germinated but failed to survive due to natural mortality or contamination.

§ Rooted plants were recovered from only 11, 5, and 5 calli of CP 72-355, CP 67-412, and CP 81-311, respectively.

¶ Number of plants per germinated caryopsis.

# Means within columns followed by the same letter do not differ significantly ($P<0.05$) by least significant difference.

In October 1989, two stalks were cut 0.9 m long from each selected subclone and planted in single-row plots (1.22 m long and 1.83 m between rows) near Houma, LA. The soil was a Mhoon silty-clay loam (fine-silty, mixed, nonacid, thermic Typic Fluvaquents) and the experiment was maintained using conventional cultural practices. The experimental design was a randomized complete block with 10 blocks. Subclones were randomly assigned to blocks. Each block (60 plots) contained subclones representative of the nine lines and a different set of 2 to 15 subclones of each line.

Data were collected in fall 1990 (plant-cane crop) on all plots for total stalks, millable stalks, stalk length (to apex), and hand refractometer brix. One 5-stalk sample of cane was hand harvested from each plot of odd-numbered blocks. Samples were cut at ground level, topped through the apex, stripped of leaf material, bundled, and tagged. The diameter of each stalk in the bundle was measured at the fifth internode from the base. Each sample was weighed and prepared in a prebreaker. Juice was extracted from a 1,000-g subsample with a hydraulic press at 1.38×10^{7} Pa for 2 min (22,27). Brix by refractometer and apparent sucrose by polarization were determined. Sucrose concentration, fiber percent cane, and yield (kg 96° sugar/Mg cane) of theoretical recoverable sugar (TRS) were calculated for each harvested plot using standard methods (2,18).

Analysis of variance was conducted assuming type (callus culture vs. shoot proliferation culture) as a fixed effect; lines and blocks were considered random effects (Table 2). Approximate F-tests for sources of variation were calculated from mean squares as defined by expectations of mean squares. Data were tested for normality using the UNIVARIATE procedure (20). Restricted maximum likelihood variance components were estimated using the VARCOMP procedure (20). Homogeneity of subclone variances was tested using the two-tailed F-test (21). Standard error for overall subclone variance was the square root of the variance of the variance estimate.

Table 2. Expectations of mean squares from the analyses of variance of total shoots and stalk weight for sugarcane regenerants.

Source of	Total shoots		Stalk weight	
variation	df	Expected mean square[†]	df	Expected mean square
Block (B)	9	$\sigma^2 + 9.0\,\sigma^2_{bl} + 60\,\sigma^2_b$	4	$\sigma^2 + 8.2\,\sigma^2_{bl} + 52.2\,\sigma^2_b$
Type (T)	1	$\sigma^2 + 8.3\,\sigma^2_{bl} + 82.7\,\sigma^2_l$ $+ Q(t)$	1	$\sigma^2 + 7.7\,\sigma^2_{bl} + 37.6\,\sigma^2_l$ $+ Q(t)$
Line/T (L)	7	$\sigma^2 + 6.1\,\sigma^2_{bl} + 61.0\,\sigma^2_l$	7	$\sigma^2 + 5.4\,\sigma^2_{bl} + 26.1\,\sigma^2_l$
B x L	72	$\sigma^2 + 6.4\,\sigma^2_{bl}$	32	$\sigma^2 + 5.5\,\sigma^2_{bl}$
Subclone	510	σ^2	216[‡]	σ^2

[†] Q indicates fixed effect.

[‡] 39 plots had missing data for harvesting and milling characters.

RESULTS

Plant regeneration

Caryopsis weight varied slightly among varieties and appeared to have little effect on germination (Table 1). Caryopses germinated rapidly as 70 to 86% germinated within 4 d of initiation of cultures (data not shown). Caryopses germinating on callusing medium generally did not exhibit radicle emergence. Callus growth was evident in 7 to 10 d. Histological study was not made, but callus growth appeared to begin at the embryonal end of the germinating caryopsis, perhaps at the scutellum (25) or shoot apex (1,4), or formed on the surface of the elongating coleoptile. Callus was typically slow-growing, white to yellow, and friable. Varieties differed significantly in frequencies of friable and mucilaginous callus types.

Embryonic shoots from calli first appeared after 6 wk, while calli were on 2,4-D medium. Varieties did not differ significantly in frequency of shoot-forming callus. Origin of the shoots was not histologically determined, but shoots appeared to arise by both embryogenesis and organogenesis. Shoot-forming calli tended to be more frequent at 6 to 8 wk than in subsequent weeks; no shoot-forming calli were produced by seedlings of CP 81-311 after 8 wk. Transfer of calli without shoots to MS1 at 14 wk did not induce significant shoot differentiation.

Rooted plants were obtained from seedlings as early as 13 wk after culture. Only 11 calli of CP 72-355, and 5 calli each of CP 67-412 and CP 81-311, produced rooted plants. Seedlings of CP 67-412 and CP 81-311 produced similar frequencies of rooted plants (nearly three plants per seed), while plant production by seedlings of CP 72-355 was nearly four times as high (11 plants per seed). Overall regeneration was 5.7 plants per germinated caryopsis. The frequency of albino or variegated regenerants was negligible, perhaps because explants were kept on callusing medium a relatively short time.

Field evaluation

As expected, lines differed significantly for most characters (Table 3). Some lines with potential agronomic merit were identified (lines 4 and 5), but most lines appeared to be deficient for one or more characters. For any given character, subclones within lines exhibited a wide range of phenotypes; subclones with an agronomically acceptable level of performance could be identified in virtually all lines. Coefficients of variability demonstrate that numbers of total shoots (CV 22.5%) and millable stalks (CV 40.1%) tended to be more variable than other characters (CV 3.5 to 8.8%).

Variance estimates and general field observation suggested that there was little consistent variation among subclones within lines for any given character (Table 4). For example, subclones of line 5 were quite variable for number of total shoots, but were comparatively less variable for stalk height. Data for most subclones within lines fit a normal distribution for each parameter. As subclone variances were heterogeneous, the variances of lines cannot be pooled to test for significance of type means or variances (21).

DISCUSSION

This study has demonstrated regeneration of plants from caryopsis-derived callus of sugarcane. Plants were regenerated from each of the three varieties tested, however, results suggested that callusing response differed among varieties. Regeneration efficiency (5.7%) was slightly better than that reported for Kentucky bluegrass, *Poa pratensis* L., in which seed of some cultivars exhibited up to 3% regeneration but several varieties had no regeneration (26). Culture of sugarcane callus under light may differentially favor shoot regeneration by an organogenic pathway (3), supporting the observation that plants appeared to develop by both embryogenesis and organogenesis. The apparent short-term regeneration ability by these calli may represent dilution and loss of adventitious shoot primordia present in the original explant (23). There was little apparent shift of friable callus to mucilaginous callus with time.

Subclones within lines represented a population varying randomly and independently about the mean for each character. Observational evidence indicated that callus and shoot proliferation culture did not differentially affect plant variability, although the comparison was not testable in a strict statistical sense. It is possible that subclones at high and low extremes of phenotypic expression may be genetically divergent. Previous work in sugarcane has indicated that sampling variation and transient phenotypic expression make it difficult to determine whether such variability has a genetic basis (8,28), although phenotypically stable regenerants have been selected for disease resistance (7,13). Results of this study show that it would be difficult to identify "true" subclone variants because of extensive sampling variation. Additional work is needed to determine the stability of agronomic characters in selected subclones.

Table 3. Means for caryopsis-derived regenerants from callus and shoot proliferation culture of CP 72-355. Subclone range is given in parenthesis.

Type/ line	Subclone[†]	Total shoots	Millable stalks	Stalk diam.	Stalk height	Hand brix[‡]	Stalk weight	Fiber	TRS
		-------- no. --------		cm	m		kg	%	kg/Mg
Callus culture									
4	100/50	21.0[§] (0-38)	18.3 (0-34)	2.47 (2.10-2.94)	2.76 (1.90-3.20)	14.8 (10.0-17.8)	1.28 (0.77-1.74)	12.2 (10.0-14.8)	112.8 (90.3-133.0)
3	20/10	20.9 (0-39)	9.2 (0-33)	1.95 (1.66-2.30)	2.08 (0.90-2.45)	15.4 (12.8-17.0)	0.69 (0.45-0.80)	11.6 (8.2-13.5)	109.3 (98.2-116.6)
5	50/18	16.8 (0-39)	13.8 (0-34)	2.64 (2.22-2.88)	2.68 (2.30-3.10)	14.9 (11.5-17.0)	1.61 (1.26-2.16)	11.3 (9.9-12.8)	116.1 (106.2-126.9)
6	150/63	16.7 (0-40)	2.3 (0-16)	2.25 (1.62-2.62)	1.99 (1.20-2.50)	8.8 (5.0-13.0)	0.73 (0.40-0.96)	11.3 (8.9-14.8)	83.9 (64.9-114.0)
1	40/16	15.4 (0-37)	1.3 (0-16)	1.96 (1.76-2.12)	1.49 (1.00-1.95)	11.7 (6.0-15.0)	0.46 (0.29-0.58)	9.4 (8.4-11.0)	111.3 (99.2-121.1)
2	50/21	15.3 (0-31)	5.7 (0-21)	2.56 (2.20-2.94)	2.03 (1.30-2.45)	13.4 (4.5-17.0)	0.96 (0.49-1.41)	9.4 (8.2-11.1)	109.3 (80.0-129.9)
Mean		17.7 ± 2.5	8.4 ± 3.7	2.30 ± 0.11	2.17 ± 0.19	13.2 ± 0.9	0.96 ± 0.15	10.9 ± 0.7	107.1 ± 4.8
Shoot proliferation culture									
8	30/15	33.0 (7-42)	28.1 (0-39)	2.14 (1.70-2.38)	2.86 (1.70-3.30)	13.0 (8.2-15.2)	1.05 (0.78-1.36)	14.8 (13.0-16.9)	76.4 (65.2-83.8)
9	100/48	19.1 (0-36)	8.8 (0-24)	2.31 (2.06-2.72)	2.34 (1.60-2.80)	13.4 (6.8-16.0)	1.02 (0.68-1.43)	10.9 (8.7-22.6)	99.3 (78.8-117.9)
7	60/20	12.2 (0-38)	3.0 (0-37)	2.07 (1.77-2.50)	1.96 (0.80-2.60)	11.4 (3.0-15.2)	0.66 (0.26-1.19)	10.0 (8.3-12.0)	92.8 (63.3-120.7)
Mean		21.4 ± 3.5	13.3 ± 5.2	2.18 ± 0.15	2.38 ± 0.27	12.6 ± 1.3	0.91 ± 0.22	11.9 ± 1.0	89.5 ± 6.8
Grand mean		18.9	10.1	2.26	2.24	13.0	0.94	11.2	101.3
LSD (0.05)[¶]		3.8	3.6	0.07	0.14	0.8	0.11	0.8	5.2
CV (%)		22.5	40.1	3.5	7.1	7.3	8.8	5.4	4.0

[†] Number of subclones planted and evaluated for total shoots, millable stalks, stalk diameter, stalk height, and hand brix. Some lines had missing data. / Number of subclones evaluated for stalk weight, fiber, and TRS.

[‡] Brix determined in standing cane at the fifth internode (from soil level) using a hand-held refractometer.

[§] Least squares means. Ranges were from actual data.

[¶] Least significant difference for comparing line means.

Table 4. Estimates of subclone variances for caryopsis-derived regenerants from callus and shoot proliferation culture of CP 72-355.

Type/ line	No. sub-clones	Total shoots	Millable stalks	Stalk diameter	Stalk height	Hand brix	Stalk weight	Fiber	TRS
				X 10^3	X 10^3		X 10^3		
Callus Culture									
5	50/18†	126.0 a‡	90.5 a	20.5 ab	18.7 d	2.3 bc	58.5 ab	0.34 b	20.4 c
1	40/16	72.8 ab	8.2 c	7.4 c	49.7 ab	4.2 ab	9.4 c	0.35 b	39.5 bc
6	150/63	72.5 b	9.9 c	26.2 a	63.3 a	3.3 b	14.6 c	1.10 a	82.7 ab
2	50/21	50.6 b	34.4 b	21.2 ab	85.4 a	6.6 a	61.6 a	0.46 b	133.5 a
3	20/10	38.0 abc	28.8 abc	21.9 ab	15.6 bcd	1.0 c	13.6 abc	2.17 a	9.1 c
4	100/50	36.9 c	46.1 b	18.5 b	39.9 bc	2.5 bc	28.0 b	0.92 ab	57.6 b
Shoot proliferation culture									
7	60/20	100.3 a	49.9 a	21.2 a	141.4 a	7.6 a	33.4 a	0.86 b	177.7 a
8	30/15	47.0 ab	57.9 a	31.0 a	52.4 b	3.4 ab	29.0 a	1.28 ab	19.6 c
9	100/48	43.8 b	31.6 a	22.8 a	35.2 b	3.3 b	36.2 a	3.79 a	76.8 b
Overall		65.8 ± 4.1	35.6 ± 2.3	22.1 ± 0.0	58.8 ± 0.0	3.7 ± 0.2	29.0 ± 0.0	1.5 ± 0.1	75.0 ± 6.7

† Number of subclones planted and evaluated for total shoots, millable stalks, stalk diameter, stalk height, and hand brix. Some lines had missing data. / Number of subclones evaluated for stalk weight, fiber, and TRS.

‡ Variance estimates within column and type followed by the same letter do not differ significantly ($P<0.05$) by pairwise F-test. Due to unequal degrees of freedom for variances being compared, the pairwise tests are not equally sensitive.

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OPERATION OF CONTINUOUS PAN AND CRYSTALLIZERS AT ST. JAMES SUGAR COOPERATIVE

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ABSTRACT

The new low grade station at St. James Sugar Cooperative was installed in stages over a period of four years. The major equipment consist of a continuous pan and two vertical crystallizers. The low grade station operated as a completed unit starting in the 1990 crop. No permanent staff was needed to operate the station. Good flow of the material by gravity through the vertical crystallizers to the continuous centrifugals was achieved without the use of viscosity reducing chemicals. The molasses exhaustion attained was very good with the average final molasses true purity about three points below the target true purity.

INTRODUCTION

The new low grade station at St. James Sugar Cooperative was planned six years ago to take care of the increase in grinding rates. At that time it was decided that the old building and existing additions had become congested with the added equipment in the series of expansions which saw milling rates increase from the original 1800 TCD to 5000 TCD in 1984. It had come to the point that a decision was made that it would be best to erect a new building for the low grade station in order to decongest the old pan floor of the low grade horizontal crystallizers and continuous centrifugal station. In doing so the target milling rate of 7000 TCD could be attained with addition of the various equipment like juice heaters, batch centrifugals, etc.

DESCRIPTION OF THE SYSTEM

The process of erection and completion of the low grade station took four years to complete and included the following:

1. Installation of vertical crystallizer No. 1 in 1987.
2. Installation of vertical Crystallizer No. 2, a new reheater, a new Western States CC-5 continuous centrifugal, and the transfer of the old continuous centrifugal station equipment to the new building in 1989.
3. Installation of a low grade continuous vacuum pan including its auxiliary tanks in 1990.

One salient feature of this station as planned from the start is that the sections should be automated to the extent that there should be no permanent operators assigned to run the station. The operation is monitored by the pan men and supervisors: their job is to change the set points in the instruments and to start/stop equipment depending on the operating conditions.

The choice of the continuous pan and vertical crystallizer came from the standpoint of manning, ease of maintenance, and ease of automation of control. The vertical crystallizers have big capacities per unit and have good features of flow compared to horizontal crystallizers. It also occupies the least amount of space for a big volumetric capacity. The continuous pan is easier to operate from the simpler automation and non-batch feature. It also has uniform demand for steam and water.

The major equipment and their specifications in the station consist of:

1. Continuous vacuum pan with its seed tank, strike receiver, and B molasses supply tank.	
Strike volume	50 cu. m. (1765 cu. ft.)
Heating surface	500 sq. m. (5380 sq. ft.)
Massecuite flow rate	315 cu. ft /hr
2. Vertical crystallizers (two units)	
Net volume	5586 cu. ft./unit
Heating surface	@180 sq. m. (1940 sq. ft.)
No. of cooling elements	@18
Capacity in series	260-330 cu. ft./hr
Massecuite in	150 deg. F
Massecuite out	105 deg. F
Cooling water	90 deg. F
3. Reheater	
Net volume	1005 cu. ft.
Heating surface	1113 sq. ft.

Continuous Vacuum Pan

A complete description of this continuous vacuum pan was given by Goddard [4]. It is of Fletcher Smith Tongaat Hulett design, rectangular in shape with a floating type calandria. It is divided into twelve compartments with six on each side. The seed enters compartment no. 1 through a speed controlled positive displacement pump and goes through the first six compartments, makes a U-turn and travels through the next six compartments. Discharge is by gravity from compartment no. 12 to a receiver on the ground floor. The height of the massecuite in the pan is controlled by a gate set manually to maintain the level at about 18 inches above the tube sheet. Each compartment has a viewing porthole, proofstick, conductivity probe, jigger steam for movement, and sight glass installation for visual monitoring of the feed. All the instruments are housed in a control panel accessible from the pan. It has a conventional tray-type condenser, vacuum jets, and gauges for temperature, vacuum, and pressure.

Instrumentation

Absolute pressure control

The vacuum in the pan is controlled by an automatic valve in the injection water line to the condenser.

Steam pressure control

The steam pressure in the calandria is controlled with an automatic butterfly valve in the steam line.

Seed pump speed

The seed pump speed is set manually according to the speed of the pan boiling as determined primarily by pressure of steam in the calandria. This speed is set by "feel" based on initial experimentation and observation of the massecuite at various compartments in the pan. There should be no false grain formation in the pan indicating not enough seed for the pan rate, and the crystal size in the compartment going to the crystallizer should be of the correct size (0.25 to 0.30 mm.). Once set this speed is varied only very little depending on the changes in processing conditions and material available in the pan floor.

Level controls

It is important that the levels of the seed supply, B molasses feed, and strike receivers be controlled to ensure smooth operation. The levels are controlled by the speed of the pumps putting in or taking out material from the tank. AC variable speed drives getting signals from level transmitters in the tanks control the speed of the pumps.

Tightness controls

The tightness or Brix control of the massecuite in each compartment is done with RF conductivity probes. The control loop consists of the conductivity probe, the electronic controller, and the automatic feed valve which operates in on-off fashion. The probes are made by SRI Australia.

OPERATION OF THE LOW GRADE STATION

The speed of the continuous pan is set based on the available B molasses in the pan floor. The parameters adjusted were primarily the seed pump speed and calandria steam pressure. The number of compartments to be fed with molasses and with water was decided upon based on the amount of B molasses in stock. We generally operated the pan at 0- 0.3 psig steam pressure, 30 - 50 % pump speed, and 2 - 6 compartments on molasses and the rest on water. Sometimes the vacuum was lowered from the standard setting of 26 inches of mercury to about 24.5 - 25 inches to slow down the pan or to check if the quality of the grains could be improved.

As a whole the operation of the station adhered to the operating guidelines as suggested by Birkett [1]:

1. Higher brixing of the C strikes.
2. Lower as much as possible the purity of the C massecuite.
3. Divert the C pan steam out to the A molasses tanks or liming tank rather than allowing it to dilute the C strike.
4. Cool down as low as possible the C strikes.
5. Reheat the C massecuite using hot water that does not exceed the saturation temperature of the massecuite.
6. Proper control of the water and steam to the centrifugals.
7. Proper operation of the C centrifugals.

We operated the continuous pan to drop at 95-96+ Ref. Bx. The purity of our C strikes depended on the purity of the grain strike and the B molasses. We went down to as low as 67 purity in our grain strikes by using A molasses in the footing and building up of the grain strike. However we were limited in the purity of our B molasses due to the fact that we wanted to maintain 97-97.5 Pol in our B sugars. We maintained our B strikes at 70-72 purity and got B molasses at 54-56 purity. We did the needed washing in the high grade centrifugals to get good pol in the B sugar. With these conditions we averaged 60.36 purity in our C strike.

Since we were operating a continuous pan we did not have low grade pan steam outs like a batch pan. However dilution of the C massecuite could also come from the addition of dilute lubricants to enhance flow in the crystallizers. Another advantage of our system is the purely gravity flow of the massecuite after pumping to the vertical crystallizers from the strike receiver. We found that high brixes of 96-97 did not hamper massecuite flow. Hence we never had to resort to adding diluted final molasses or pan additive solutions to lower the viscosity of the cooled massecuite along the crystallizers to make it flow better. This practice has a deleterious effect on the purity of the final molasses due to the purity increase incurred in the reheaters. In a study we did with Audubon Sugar Institute in 1987 [3] we found that we had a partial dissolution of the C sugar crystals in the reheater. This was traced back to the slight dilution of the C massecuite by aqueous solution of pan additive which we mixed with the cooling C massecuite to aid its movement and flow in our old horizontal crystallizers.

The combined volume of our vertical crystallizers gave us 38 to 48 hours retention time for cooling. Our cooling system is completely counter-current and we never encountered any problem of cooling down to our target temperature of 98-100 deg. F. As a matter of fact for a time we cooled to as low as 90 deg. F until other constraints prevented us from continuing this practice.

The design of our reheater allowed us to use heating water at 135-145 deg. F in the heating coils to heat the C massecuite to 120-130 deg. F. We believe that we minimized whatever remelting of sugar crystals was present with the conservative design of the reheater.

In the continuous machines we were able to lower down the purity increase with optimizing water to the feed rod, steam to the screen wash and to the halo pretreatment, and maximum loading while maintaining magma purity of 85-87. As much as possible we preferred operating the higher capacity CC-5 machine rather than the CC-4 machine because in our experience the purity pick-up of final molasses was less in the CC-5. The design of our station gave us plenty of head of feed to the machines such that feeding the machines at high rates with our highly viscous C massecuites was maintained without any trouble at all. We were able to maintain an average of 20 feet of head of massecuite to the feeding valve of our low grade machines.

OPERATING RESULTS

One of the best parameters to gauge low grade station operation in Louisiana is the result of final molasses exhaustibility studies done annually since 1981 by the Audubon Sugar Institute at LSU. Starting in 1987 ASI used a new exhaustibility formula for Louisiana molasses with High Pressure Liquid Chromatography analyses of % sucrose and inverts in the final molasses samples [5]. Final molasses samples were composited daily for two halves of the entire crop and sent to ASI for analysis in the 1987, 1988, and 1989 crops. For the 1990 crop weekly composite samples were made. The results of these weekly composites are shown in Table 1. On the first week the Δ Target was -0.56. This was the lowest of the season and included molasses from purged fresh C massecuite in order to get magma immediately on the first days of grinding for footing of the high grade strikes. This also included some C massecuite with wide variations of grain size which came from experimenting over the rate of seed pumping and also from the non-uniform C strikes coming from both the batch and the continuous pans for 36 hours during the commissioning of the continuous pan. After the continuous pan was put on line on the third day of grinding we gradually brought the low grade operations to normal. On the second week we increased the brixes to 96-97 and cooled to 90 deg. F. in the crystallizer. On this week we attained the biggest exhaustion of -4.20. We observed that the C massecuite was quite viscous and we had difficulty getting good magma of 85 purity. We also noticed the heating up of the gear drive up to a point wherein it vibrated. At this point we lowered our brix to 95-96 and increased the final crystallizer temperature to 100 deg. F. This cured the problems in the gear drive and we operated within these parameters for the rest of the crop in which the exhaustion ranged from -2.41 to -3.72. The crop average was -2.91 points below the target true purity.

A comparison of the exhaustibility data from 1987 to 1990 is shown on Table 2. The 1990 average Δ Target of -2.91 is a big improvement over the three previous years wherein we were always above target. This table also shows the gradual improvement as we put new equipment since 1987. The improvement in 1988 came from the avoiding of partial resolution of the sugar crystals in the reheaters and by better operation of the old Western States CC-4 continuous centrifugals. Partial resolution of crystals in the reheater was avoided by not putting any dilution causing light aqueous solution of pan additives in the cooling C massecuite in the old horizontal crystallizers. This effect was found out in the 1987 study of our low grade system done in cooperation with ASI. In 1989 we had a very small improvement with the addition of the second vertical crystallizer, new reheater and a new Western States CC-5 centrifugal. This probably reflects the limitations of our pan boiling due to the limited pan capacity. Our pan capacity was barely adequate for 5000 TCD and remained the same even though we increased milling from 5000 to 6000 TCD. The addition of the continuous pan alleviated this condition in 1990 and showed the advantage of this kind of pan to produce well boiled low grade strikes. The improvement in low grade boiling is shown in Table 3. There is a big increase in purity drop of the low grade massecuite in the pan accompanied by a decrease in the purity drop in the crystallizers.

It should be noted that these apparent purities came from different methods of sample clarification. Lead subacetate was used in 1989 while lead substitute [2] was used in 1990. There are differences in the results from the purities from both methods on the same sample and the differences vary on the nature of the samples analyzed. The % Total Sugars as Invert at 79.5 % Bx also dropped significantly for the two years from 47.98 to 44.11, a 3.87 points improvement. It is also worthwhile to note that we did not experience small lumps or balls of massecuite in the C strike as reported in other mills using continuous pans for low grade [6].

Table 1. Molasses exhaustibility 1990 crop.

	Nov. 1-10	Nov 11-17	Nov 18-24	Nov 25-Dec 1	Dec 2-8	Average
Ref. Brix	82.10	81.6	80.4	80.8	80.6	81.08
App. Pty	37.10	33.46	36.76	38.16	38.71	36.84
% Glucose	3.26	2.76	2.06	1.80	2.02	2.38
% Fructose	6.87	6.38	5.16	4.64	4.84	5.58
% Red Sug	10.13	9.14	7.22	6.44	6.86	7.96
Cond Ash	12.68	13.68	13.27	14.12	13.61	13.47
RS/Ash Ratio	0.80	0.69	0.54	0.46	0.50	0.60
True Solids	80.93	80.53	79.35	79.75	79.55	80.02
True Sucrose	34.83	32.24	34.31	34.24	33.68	33.86
True Purity	43.04	40.16	43.24	42.93	42.34	42.34
Target Pty	43.60	44.36	45.65	46.59	46.06	45.25
Difference	-0.56	-4.20	-2.41	-3.66	-3.72	-2.91
Total Sugars	44.96	41.68	41.53	40.68	40.54	41.88
T S I	46.79	43.18	43.34	42.48	42.31	43.62
TSI @79.5 Bx Lane-Eynon	47.17	44.17	44.13	42.58	42.29	44.11

Table 2. Comparison of exhaustibility data.

	1987	1988	1989	1990
Rs/ash Ratio	0.830	1.10	0.825	0.60
Target True Purity	43.45	41.90	43.40	45.25
F. Mol True Purity	45.85	42.15	43.55	42.34
▵ Target	2.40	0.25	0.15	-2.91

Table 3. Comparison of low grade data 1989 and 1990.

	1989	1990
Out of the pan		
Purity of C massecuite	62.38	59.98
Purity of Cycl. Mol.	47.57	40.94
Cured C Massecuite:		
Purity of C Massecuite	61.82	59.71
Purity of Cycl. Mol.	37.54	35.45
Final Molasses Purity	39.74	36.95
Purity Drop:		
Across Pan	14.81	19.04
In vertical cryst.	10.03	5.49
In continuous cent.	(2.20)	(1.65)
▵Target	0.15	(2.91)
Total sugars as invert at 79.5 Bx	47.98	44.11

Note: 1989 Purities were done with lead subacetate 1990 Purities were done with lead substitute

CONCLUSION

Our results from the first year's operation of our fully completed low grade system station showed a big improvement in our losses to final molasses. These improvements could be traced to better exhaustion in the pans and crystallizers and lower purity increase in the continuous centrifugals.

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SUGARCANE FULL-SIB FAMILY YIELD PLOTS FOR ESTIMATING GENETIC VARATION IN ELITE HAWAIIAN CLONES[1,2]

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ABSTRACT

The usefulness of planting full-sib (FS) families in yield plots as an alternative to clonal plots was investigated. A North Carolina Mating Design I was used with eight males, each mated to two females. The 16 FS families and two commercial check cultivars were planted in a randomized complete block design with three replications at the Hawaiian Sugar Planters' Association (HSPA) substation at Kunia, Oahu, Hawaii. Significant additive genetic variation was detected for four of the five traits measured. The best yielding family produced 88% of the cane [kg ha^{-1}] produced by the average of the check cultivars. Information on the best combining parents was obtained. Heritabilities were low for all traits measured. This procedure could save a considerable amount of time in evaluation of parents.

INTRODUCTION

The selection program for sugarcane varietal development in Hawaii typically requires ten to 15 years from crossing to release of a new cultivar. Early selection is based on visual evaluation and requires four years before the clone is placed in a preliminary yield trial (FT5). Wu (1982) reported correlation coefficients in FT5 tests between cane volume at seven months and cane yield [kg ha^{-1}] at two years from -0.07 to 0.68. He concluded that seven month stalk volume could not be used as a predictor for yield of two year cane and that visual selection should emphasize elimination of clones with commercially unacceptable traits. Meyer et al. (1982) investigated the efficiency of visual selection in advancing superior seedlings into FT5 yield trials. Three groups of seedlings were produced, one from normal selection, one considered the second best, and one selected totally at random. All groups were screened for smut (*Ustilago scitaminea* Syd) and pineapple disease (*Ceratocystis paradoxa* Dade) and only resistant clones advanced to FT5. The percentage of superior seedlings in the random group was 36% while the percentages from normal selection and second best selection were 41% and 27% respectively. Wu and Tew (1985) further confirmed the inability to predict sugar yield from visual selection.

The selection program for developing breeding materials is based on the results of FT5 yield trials. Genotypes that yield more than the check varieties are selected. The determination of elite parents for making crosses is based on the results of further advanced yield trials (FT7s) of the parents and their progenies. The elite combining parents are inferred from the number of high yielding progenies in FT5s and FT7s. However, this method of evaluation has no systematic control over the number of progeny selected from a given parent through the stages of visual selection.

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[2] Joint contribution from the Hawaiian Sugar Planters' Association and USDA - ARS National Clonal Germplasm Repository, Miami, FL.

Progeny from superior crosses or parents may be under-represented in FT5 and FT7 yield trials by chance or because of abias for plant phenotype or growth habit in the selector. The alternative method, which is used by many sugarcane breeders, is to compare the selection rates during early stages of visual selection when the numbers of progenies of crosses can easily controlled to equal. Because of the two-year cropping system in Hawaii, Wu and Tew (1989) used a third method. They planted equal number of progenies in FT5s as families which allowed them to skip years of visual selections, and evaluated the crosses based on the family (not individual) yield measured after two years of growth.

Any reduction in the visual selection cycle or increased efficiency in identifying superior parents would result in reduced cultivar development time and hence in reduced cost. Our objectives were to test the feasibility of planting seedlings (full-sibs) directly in FT5 yield trials. Individual full-sibs (FS) from superior families could be propagated from vegetative seed from the ratoon crop and advanced as clones. Information on which parents combine best would be established and time would be saved on the visual selection cycle.

MATERIALS AND METHODS

A North Carolina Design I crossing scheme (Comstock and Robinson, 1948) was used to produce the full-sib families. Eight males were crossed with a different pair of females; the females were nested within males. Crosses were made at the HSPA breeding station, Mauawili Valley, Oahu, during the 1985-86 crossing season (Nov-Jan). Crosses were made using the standard biparental technique. All males and females were either current commercial, past commercial, or elite breeding lines that have made yield gains in FT5 tests against current commercial clones. Seeds were germinated and transferred to flats with 24 seedlings/flat. The seedlings were transplanted at seven months of age into the field in August 1986.

Full-sib families were planted in a randomized complete block design with three replications. Plots consisted of six rows spaced 1.5m apart with seven plants in each row spaced 1.0m apart. Two standard commercial Hawaiian varieties, H62-4671 and H65-7052 were included in each replication as checks. Vegetative seed of the check varieties was planted at commercial seedling densities. The experiment was planted at the HSPA substation located at Kunia, Oahu. Fertilization was the same as current plantation practice.

Plots were harvested as mature cane by hand by cutting the inner two rows of each six row plot and weighing the stalks. Cane yield [kg ha^{-1}], refractometer solids (%), polarity (%), purity (%), and sugar yield [kg ha^{-1}] were estimated using current commercial practices of the Hawaiian sugar industry (Payne 1968). All computations were performed using SAS (1985) procedures. Data were subjected to analysis of variance assuming the following random statistical model (Comstock and Robinsion 1948).

$$Y_{ijk} = u + \text{Replication}_i + \text{Male}_j + \text{Female}_{k(j)} + \text{Error}_{ijk}$$

Additive genetic variance was estimated using the following mean squares from the AOV:

$$1/4\ \sigma^2_A = MS_{males} - MS_{females}/6$$

Heritabilities were estimated using the among full-sib families mean square divided by the number of replications, three, as the phenotypic variance and the estimation of the variance of males as a estimate of 1/4 of the addivite genetic variance within the populations:

$$h^2 = 1/4\ \sigma^2_A / [MS_{among\ FS}/3]$$

The inbreeding coefficient (F) was assumed to be zero. Standard errors of variances and heritabilities were estimated using the methods of Haullauer and Maranda (1981).

RESULTS AND DISCUSSION

The checks were significantly different from the full-sib families for all characters. The checks did not significantly differ between each other. Significant differences were detected among male half-sib families for all characters except sugar yield. No differences were found among female or replication sources of variation (Table 1). The significant variation among males indicates that additive genetic variation exist for these traits. The current use of the "melting pot" polycross system is based on significant additive variation and its use is supported by these results. The lack of significance among females may be due to the limited genetic variation among current Hawaiian elite breeding clones, genotype x environment interactions, which could not be estimated in a single environment, or the small number of families evaluated. Despite the non-significant F test among females, differences of up to 25% of cane yield were found between females crossed to the same male.

Table 1. Mean squares from analysis of variance of agronomic and stalk chemical characters from the Design I experiment.

Source	df	RFSOL %	POL %	PUR %	CANE kg ha^{-1}	SUGAR kg ha^{-1}	EMS***
Reps	2	1.97	2.60	8.23	251.60	2.99	
Among Full-Sib Families	15	4.87**	6.76**	19.55**	933.12**	35.33**	
Males	7	5.67**	7.64**	20.38 *	749.56*	14.56	$\sigma_e^2 + 3\sigma_f^2 + 6\sigma_m^2$
Females(m)	8	1.72	2.60	10.67	434.54	12.15	$\sigma_e^2 + 3\sigma_f^2$
FS Families vs Checks	1	29.14**	40.08**	103.84**	7041.40**	396.36**	
Check 1 vs Check 2	1	0.28	0.66	0.42	98.41	5.04	
Error	34	1.61	2.13	6.38	284.68	6.56	σ_e^2
TOTAL	53						
C.V.		6.77	9.18	2.98	14.85	17.72	

*,** Significant at 0.05 and 0.01 levels, respectively

*** Genetic Interpretation: $\sigma_m^2 = \text{COV HS} = \frac{1}{4}\sigma_A^2$

$$\sigma_f^2 = \text{COV FS} - \text{COV HS} = \frac{1}{4}\sigma_A^2 + \frac{1}{4}\sigma_D^2$$

Refractometer solids varied from 16.6% to 20.4% for the FS families. The highest reading was from CFS-21. Polarity varied from 13.4% to 17.1%. Purity varied from 71.9% to 86.9%. The check varieties yielded an average 326,704 [kg ha^{-1}] cane and 49,537 [kg ha^{-1}] Sugar. The best FS family, CFS-22, produced 290,147 [kg ha^{-1}] cane and 35,683 [kg ha^{-1}] sugar, which was 88% and 72% of the mean of the checks, respectively. The population as a whole produced 75% of the mean of the checks for cane yield. The family with the greatest sugar yield, CFS-31, produced 74% of the mean of the check varieties. The highest cane yield among males was H67-0803 followed by 71-3958 (Table 2). The highest sugar yield among males was also H67-0803 followed by 70-144 (Table 2).

Sugar yield gains in Hawaiian commercial clones have come from selecting greater biomass-producing genotypes and not from increases in percent sucrose (Tew 1987). Selection among the parents for inclusion in future crosses should be based on KCH. These results suggest that H67-0803, H71-3958, and H75-2582 would be superior parents in polycrosses and their use should be expanded. Although the female soure of variation was not significant for any character, several FS families, CFS-22, CFS-61, CFS-42, CFS-82, and CFS-31, produced high cane yield. These biparental crosses should be repeated to produce large numbers of seedlings for evaluation.

Table 2. Mean agronomic performance and stalk chemical composition of full-sib families and check cultivars.

Type	Female	Male	RPL	RFSOL %	POL %	PUR %	CANE kg ha^{-1}	SUGAR kg ha^{-1}
Clone								
H62-4671			3	20.6	18.3	88.3	317632	47488
H65-7052			3	21.0	18.7	88.8	335776	51587
			$\bar{x}$	20.8	18.5	88.6	326704	49537
Cross								
CFS-11	H62-4671	H61-1820	3	19.7_{a}	17.1_{a}	86.9_{a}	228704_{abc}	32099
CFS-12	H63-4342	H61-1820	3	19.4	16.6	85.4	242278	31808
CFS-21	H71-7581	H67-0803	3	20.4_{a}	17.7_{a}	86.7_{a}	250656_{a}	35392
CFS-22	H63-4729	H67-0803	3	18.6	15.7	84.6	290147	35683
CFS-31	H32-8560	H70-0144	3	20.0_{ab}	17.2_{a}	86.0_{a}	264835_{ab}	36736
CFS-32	H53-0263	H70-0144	3	18.7	15.7	83.7	246982	30755
CFS-41	H66-2689	H71-3958	3	18.3_{abc}	15.6_{abc}	85.0_{ab}	258630_{a}	31718
CFS-42	H66-4927	H71-3958	3	17.9	14.7	82.1	274758	31203
CFS-51	H76-5956	H73-8505	3	18.42_{b}	15.8_{ab}	85.6_{a}	174854_{c}	22243
CFS-52	H77-6064	H73-8505	3	19.3	16.7	86.1	229286	31046
CFS-61	H68-0388	H75-3257	3	17.3_{c}	15.3_{c}	82.6_{b}	276035_{ab}	31584
CFS-62	H73-6110	H75-3257	3	16.6	13.4	80.6	235200	24707
CFS-71	H72-1040	H75-8776	3	17.6_{abc}	14.6_{abc}	82.3_{ab}	183590_{bc}	20518
CFS-72	H76-4713	H75-8776	3	18.1	15.4	85.0	248035	30307
CFS-81	H60-3857	H75-2582	3	16.9_{bc}	13.4_{bc}	79.1_{b}	249603_{ab}	25088
CFS-82	H62-7740	H75-2582	3	18.4	15.5	84.0	272451	33376
MEAN				18.5	15.6	84.2	245377	30266

a,b,c Duncan Multiple Range Test for differences among males based on the mean for the two crosses. Alpha = 0.05.

Heritabilities were low for all measured traits (Table 3) this may be due to environmental effects which inflated the phenotypic variance. The additive genetic variance was based on F = 0. This assumption is known to be incorrect. Two of the females, H73-6110 and H60-3857, are direct descendants, two generations removed, from H32-8560. The heritabilities of traits in two year cane have not been reported before. The low estimates of heritability indicate that the most efficient unit of selection for these traits is the family.

The experiment was conducted for 24 months at a single location; therefore, environmental effects cannot be estimated. The results of the experiment indicate that more Design I or Design II matings should be made. These could provide a estimate of the environmental effects which are known to be significant in sugarcane (Hogarth et al. 1981, Schnell and Nagai 1992). The use of Design I or Design II matings to eliminate poor general combining parents from the melting pots would increase the frequency of superior seedlings produced and give specific information on which parents produced superior families.

Table 3. Estimates of additive genetic variances and heritabilities for agronomic and stalk chemical characters.

	RFSOL %	POL %	PUR %	Cane Yield [kg ha^{-1}]	Sugar [kg ha^{-1}]
$\frac{1}{4}\sigma^2_A$ ± SE	0.66 ± 0.46	0.84 ± 0.63	1.62 ± 1.78	52.50 ± 67.20	ns
h^2 ± SE	0.40 ± 0.41	0.37 ± 0.28	0.25 ± 0.27	0.17 ± 0.22	ns

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SURVEY AND ESTIMATED DAMAGE ASSESSMENT OF THE MEXICAN RICE BORER IN TEXAS

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Injury due to the Mexican rice borer (MRB), *Eoreuma loftini* (Dyar), was surveyed in 20 Lower Rio Grande Valley (LRGV), Texas sugar cane fields during 1989, and 40 fields during 1990. Samples (25 plants or stalks) were taken in 4 locations within each field. Results in 1989 suggested higher injury to stalks in western valley fields than in eastern fields, but there were no significant differences in samples taken within fields. The cultivar NCo 310 had slightly higher injury than CP 70-321, and there was an overall valley average of 19 percent bored internodes. Results from 1991 again showed higher injury in the western valley fields. Stalks from 'NCo 310' had statistically higher levels of injury than 'CP 70-321' (23.5 vs 16.7 percent, respectively), with an overall valley average of 20.9 percent bored internodes. Regression analysis of earlier studies suggested that for each 1 percent MRB-bored internode, 118 lbs. of sugar per acre (0.059 tons) could be lost. These economic analysis results represent a preliminary attempt to provide LRGV growers with damage assessment due to MRB.

EVALUATION OF COMMERCIALLY AVAILABLE SUGARCANE BILLET PLANTERS IN EGYPT

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Four types of the one row sugar cane billet planters were evaluated on the basis of planting uniformity, cutting damage, and planting costs. A systematic approach for categorizing planting uniformity (based on gaps, desirable and excessive seed distribution) was developed. The results indicate that the planters did not achieve the planting uniformity desired by sugarcane producers.

Performance differences between planters were attributed to the planter design more than the machine variables and the operation conditions. The "pto driven cutter" planter gave non-uniform distribution due to the high percentage of both gaps and excessive seed use. The poor uniformity of the "ground wheel driven cutter" planter was mainly due to high percentage of gaps and less than adequate quantity of seed. The "automatic drop planter" provided adequate seed quantity however its planting uniformity was poor due to gaps. The damage to the buds for all the planters was less than 4 percent, which was not a critical factor in the evaluation. The cost of the planting operation of automatic drop planter was more than the other planters due to its low efficiency.

ESTIMATING TONNAGES OF COMMERCIAL SUGAR CANE FIELDS

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Sugar cane managers seek accurate tonnage estimates before harvesting commercial fields. They use estimates daily to pay cutters and determine how many fields to burn. Also, they use estimates to select starting and finishing dates for their grinding seasons. Average estimates of an entire season are often accurate, but may lose accuracy due to natural causes like newly arrived pests. Moreover, estimates of specific fields are not consistently accurate throughout a grinding season.

The purpose of this study was to compare a statistically oriented sampling procedure with the system now in use. Stalk heights and diameters were measured on 40 stalks per 40 acre field. Stalk number was counted at 30 locations within each field. All measurements came from randomly chosen stalks selected from five predetermined blocks in each field. A crew of four workers normally completed the measurements required for one field in about one hour. The new procedure was more expensive and time consuming than the standard procedure, but not more accurate. It did not improve the consistency of tonnage estimates of individual fields.

Mills should not routinely use the new system to estimate cane tonnage. However, the success of the standard system is based largely on yield history. Therefore, for fields without extensive yield histories, the sampling system could be useful. Also, farmers could collectively use the new sampling system on a small scale to verify that yields are at expected levels.

SUGARCANE CULTIVAR RESPONSE TO LIMESTONE APPLICATION ON EVERGLADES HISTOSOLS

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In the Everglades Agricultural Area, sugarcane production fields are influenced by limestone parent materials which underlie nearly 90 percent of the soils. From 12 to 17 percent of the area of typical production fields are influenced by these parent materials mixed into surface soils along canal spoil banks and farm roads. The sugar cane cultivar response to limestone application was investigated on an acid (pH 4.8) Pahokee muck. Five rates of limestone (0,4,8,16 and 32 tons/acre) were incorporated and four cultivars (CP72-1210, CP78-1247, CP74-2005, and CP65-357) were planted in 1988 using a randomized complete block design with 4 replications.

As a result of liming, after 2-3 years soil pH changed from 4.8 to 7.4. Except for first-ratoon yields of CP72-1210, plant cane and first ratoon yields of all cultivars were unaffected ($P \leq 0.05$) by application of limestone. During the first-ratoon crop, application of limestone increased cane yields of CP72-121 as much as 37 percent and sugar yields as much as 34 percent. The impact of liming parent materials in an acid Histosol was shown to have a little to no effect on the yields of most cultivars.

PERFORMANCE OF THE SUGAR CANE VARIETY LHo83-153 IN REPLICATED YIELD TRIALS IN LOUISIANA

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The sugar cane variety LHo83-153 is a selection from the progeny of the cross CP77-405 x CP74-339. The cross was made in 1978 at the USDA facility in Houma, Louisiana. Seedlings were planted, selected and advanced at the St. Gabriel Research Station, St. Gabriel, Louisiana by personnel of the Louisiana, "L" Variety Development Program; thus the prefix "LHo."

LHo83-153 was grown in 13 outfield variety trials in Louisiana from 1988 through 1990, where it was compared to commercial varieties CP79-318. Results from 122 plant cane, 76 first ratoon and 27 second ratoon observations indicate that LHo83-153 compares favorably to the commercial varieties in yield and sugar content in both heavy-textured soils. Observations indicate LHo83-153 is moderately adapted to mechanical harvesting.

LHo83-153 can be classified as resistent to sugar cane mosaic virus and resistent to the sugar can borer. It appears moderately susceptible to sugar cane smut.

REGENERATION AND PHENOTYPIC VARIABILITY OF PLANTS CULTURED *IN VITRO* FROM MATURE SUGAR CANE CARYOPSES

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Laboratory and field studies were conducted to determine regeneration efficiency and phenotypic variability of subclones derived from *in vitro* culture of mature sugar cane caryopses. Selfed (S1) caryopses of three varieties (CP 67-412, CP 72-355, and CP 81-311) were subjected to callus culture (Murashige and Skoog [MS] medium with 2,4-D) or proliferation culture (MS medium with shoot proliferation hormones). Varieties differed in percent germination and in frequencies of non-shoot-forming friable and mucilaginous calli, but not in frequency of shoot-forming callus. Regeneration from callus averaged 5.7 (range 3 to 11) plants per germinated caryopses across varieties. Subclones from nine caryopses (lines) of CP 72-355 were examined for variability in the plant-cane crop.

There was substantial variability among subclones within lines. Data for most subclones within lines fit a normal distribution for each parameter.

Among lines, subclone variances were heterogeneous and appeared to vary randomly and independently about the mean. Empirical evidence suggests that variances are not greatly affected by culture procedure. Results demonstrated that callus cells of mature caryopses are totipotent and that variety affected the regeneration response. Identification of agronomically useful subclone variants would be difficult because of sampling variation.

SUBSURFACE DRAINAGE: A PROFITABLE SUGAR CANE PRODUCTION PRACTICE

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Subsurface drains were installed on Jeanerette silty clay loam soil in Iberia Parish, Louisiana to evaluate soil and crop responses to subsurface drainage. During 1980 through 1990, three cycles of sugar cane (9 crops) were grown on subsurface drained and nondrained areas. The water table in both areas fluctuated within 4 feet of the soil surface most of the time, with the water table in the nondrained area fluctuating much closer to the soil surface.

Sugar yields from a drained area (low water table) with subsurface drains spaced 90 ft. apart were higher than those from nondrained area (high water table) six of nine crops. Sugar yield increases ranged from 669 to 2273 lb/A (14 to 172 percent). At today's sugar prices, an accumulated yield increase of 2500 lb/A is required to pay for subsurface drainage ($325/A).

During this test, accumulated sugar yields from 9 crops in the drained area exceeded those from the nondrained area by 7720 lb/A, which was 3 times that needed to pay for the subsurface drains. In two cases, yield increases from the drained areas accumulated to more than 2500 lbs/A in only two crops. During the three crops when sugar yields from drained and nondrained areas were similar, rainfall was relatively low, consequently, the water table was not high enough to adversely affect the cane roots and crop yield. This study confirms that subsurface drainage of Jeanerette silty clay loam soil is a profitable practice in sugar cane production.

Contribution from the Soil and Water Research Unit, USDA-ARS Baton Rouge, Louisiana, in cooperation with the Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge.

PERFORMANCE OF TWELVE SUGAR CANE CULTIVARS GROWN ON ORGANIC SOIL AND SUBJECTED TO MECHANICAL HARVESTING

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Twelve commercial sugar cane cultivars were grown in replicated plots at the Everglades Research Education Center in Belle Glade. The cane was planted on December 22-23, 1987, and harvested with an Austoft 7700 mechanical harvester for three annual crops. Cane weights were determined for each plot. Samples of stalks were collected from each plot for juice quality determinations. Using juice quality factors and net cane weight, estimated sugar yields were calculated for each replicated plot. Additionally, ratings were made on cane erectness/adaptability for mechanical harvesting.

Certain cultivars outperformed other cultivars, particularly after 3 years of mechanical harvest. The cane was ratooned and rated after the last harvest for potential yield (stand). Based on these ratings and stand counts, the best cultivar for the fourth crop was CP80-1827 with CL73-239 and CP80-1743 also, providing acceptable stands. The worst performing cultivar was CP78-2114 which began the experiment with a poor stand.

ESTIMATION OF SUGARCANE FAMILY POTENTIAL TO PRODUCE AN ELITE CLONE

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Estimates of the family potential to produce elite clones are essential to efficacious use of breeding resources. The current method of using percent advancement requires too much time and wastes resources. Development of a faster and practical sugarcane cross appraisal method was studied by appraising 1800 progeny from 15 crosses among 23 parents at two intrarow plant spacings. Data were collected on plant cane (PC) and first ratoon (FR) single stool seedlings, and first clonal (FC) plots.

The family mean, the normal probability of a elite proportion (PROB) and the best linear unbiased predictors (BLUPs) were estimated for single yield component traits for each family. The calculated statistics were strongly correlated among themselves within the PC, FR and FC tests ($0.69 \leq r \leq 1.00$). Family worth estimates based upon single stool data moderately correlated to the clonal family worth estimates. The correlations suggested that the potential to produce an elite clone with a specific superior trait could be accurately predicted by the cross mean with little loss of accuracy compared to the PROB estimate. Correlations of the PC and FR tests with the FC test suggested that the PC estimates could in many case be used to make cross appraisal estimates. This would enable selection among families before the normal selection within families occurs in the first ratoon crop and hence further improve the efficiency of the breeding program. The research also suggested use of wider intrarow spacing may improve selector ability to discern among seedlings due to its enhancement of stool weight variability.

Families were additionally evaluated for their potential to produce elite progeny in two traits. This bivariate appraisal was made with three statistics. The first method was the sum of the family ranks based upon the family mean values for the two traits (RANK). The second method was the bivariate BLUP and the third method was the bivariate normal probability of elite progeny (PROB). The PROB was estimated with family means, standard deviations and genetic correlations. BLUPs and RANKs showed good repeatability among tests while the PROB generally demonstrated poor repeatability among tests. The predictions were also compared to the selection rate of seven of the 15 crosses. The results illustrated that joint prediction for Brix and stool weight by means of BLUP and RANK gave reasonable indications of the value of the cross. PROB was not consistent in this regard. The comparative ease to calculate the RANK estimate versus the BLUP with no apparent loss of predictive value suggested that the RANK method would be the best statistic to make bivariate predictions.

ECONOMIC THRESHOLD RESEARCH WITH THE YELLOW SUGAR CANE APHID IN SUGAR CANE

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Small plot studies were used to investigate the relationships among densities of the yellow sugar cane aphid, *Sipha flava* (Forbes), during early, middle, and late season sugar cane, *Saccharum officinarum* L., (variety CP65-357) developmental stages at two locations. Three-fold differences among aphids (enhanced vs. suppressed) were observed during early season, while tenfold differences occurred during middle season at Westfield Plantation, Paincourtville, LA. With a mean of 5.73 and 30.85 (10 replications) aphids per leaf per week during early season and middle season, respectively, losses were 501 and 630 pounds of sugar per acre. Sugar cane which had both early and middle season infestations resulted in a 707 pound per acre sugar reduction. Late season aphid populations were not sufficient for-damage assessment. Insecticidal enhancement of sugar yields in the absence of aphids was not observed.

POPULATION LEVELS OF PLANT PARASITIC NEMATODES ASSOCIATED WITH SUGAR CANE IN FLORIDA

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A survey during 1983-1989 was conducted to assess population levels of plant-parasitic nematodes associated with commercial sugar cane fields in south Florida. Twelve different genera of nematodes were commonly associated with sugar cane, and several of these genera were usually present together in a complex. The species complex varied depending on soil type. Sheath, sheathoid, awl, and lance nematodes only occurred in sand soils. Root-knot and stubby-root nematodes were more abundant in sand soils while stunt nematodes were more abundant in muck soils. Spiral, ring and lesion nematodes were generally as prevalent in muck as in sand soils. More than 2000 nematodes (all types in a complex) per 100 ml soil were sometimes present in commercial fields. Densities of each nematode genus observed were reviewed. Data from the survey form a base to which nematode levels observed in future samples can be compared.

INHERITANCE OF RATOONING ABILITY AND THE RELATIONSHIP OF YOUNGER CROP TRAITS TO OLDER CROP TRAITS

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Good ratooning varieties are essential to the economic success of sugarcane growers. Ratooning ability was defined as the second ratoon crop cane yield percentage of the plant cane crop. Thirty-four experimental varieties and three commercial checks were grown at four locations for two, three-crop series from 1983 through 1987. Broad-sense heritabilities and genetic correlations were estimated from variance components. Genetic path analysis was used to further examine relationships between crops. Single-plot based heritabilities for cane yield (TCH) and its components, stalk number (POP) and stalk weight (WT), were low ($H_{TCH} = 0.17$, $H_{POP} = 0.11$ and $H_{WT} = 0.06$) but increased substantially with replication. Error variance was four to 30 times larger than the genotypic variance for all traits. Genotype by environment variation was less important than genetic variance in determining the phenotypic variance. The major determinate of cane yield within a crop is stalk number.

Genetic correlations and path analysis among traits in different crops demonstrated that, as expected, stalk number of earlier crops was the primary determinate of subsequent stalk numbers and cane yield in older crops. Correlations were very high between adjacent crops ($0.85 \leq r_{TCH} \leq 0.90$; $0.90 \leq r_{POP} \leq 0.93$; $0.94 \leq r_{WT} \leq 0.97$) but were reduced between the plant cane and second ratoon crops ($r_{TCH} = 0.56$; $r_{POP} = 0.69$; $r_{WT} = 0.85$). The correlation between stalk number and stalk weight was negative in young crops and weaken in older crops ($r_{\text{plant cane}} = -0.41$, $r_{\text{1st ratoon}} = -0.29$, $r_{\text{2nd ratoon}} = -0.01$). Sucrose content and its components were not a factor in ratooning ability nor were they affected by crop age although they did demonstrate moderate egative correlations ($-0.48 \leq r \leq -0.58$) with stalk diameter and moderately weak negative correlations ($-0.19 \leq r \leq -0.40$) with stalk weight.

Average varietal cane yield decreased 29% from plant cane to second ratoon crop. Stalk number decreased 25% while stalk weight decreased 33%. There was considerable varietal variation in these responses. The results suggested that varietal cane yielding ability in older crops can be accurately predicted in immediately preceding crops and that ratooning ability could be selected almost as easily as cane yield. Large error variance will require selectors to well replicate to be fairly confident that selection made for high yielding first ratoon varieties will also be high yield second ratoon varieties.

OCCURRENCE OF SUGAR CANE BACILLIFORM VIRUS IN A FLORIDA VARIETY COLLECTION

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Four hundred thirty-one varieties maintained in a germplasm collection by the United States Sugar Corporation were assayed by ELISA, and in a limited amount of samples, by electron microscopy for the presence of sugar cane bacilliform virus (SCBV). All of the current commercial varieties, many of the older Florida commercial varieties, varieties of significance in the two Florida breeding programs, varieties of historical importance, and a collection of recently introduced foreign varieties were assayed. SCBV was detected by one or both methods in four noble varieties (*Saccharum officinarum* L.) and 20 interspecific hybrids (*Saccharum sp.*) including two varieties from Canal Point (USDA-ARS), four early Florida varieties (Univ. of FL.), one Hawaiian variety, and thirteen foreign varieties. All of the infected Florida varieties were early generation varieties from the 1930-40's. None of the current commercial varieties were infected. In addition to the variety survey, six varieties were sampled at monthly intervals for nine months to determine the seasonal variability in virus titer as determined by ELISA. Over all varieties, the virus titer was highest in July and August and then declined to barely detectable levels by late November. The decline in virus titer appeared to be temperature related. This information will be valuable in future studies to detect SCBV.

DEVELOPMENT OF A RELATIVE SURVIVAL INDEX FOR ASSESSING VARIETAL RESISTANCE TO THE SUGAR CANE BORER

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For more than 40 years, the primary criterion used to rate sugar cane varieties for resistance to the sugar cane borer, *Diatraea saccharalis* (F.), in Louisiana has been percent bored internodes. This assessment, to determine the degree of external evidence indicative of stalk tunneling, traditionally has been undertaken during the outfield stage of varietal evaluation. This phase occurs more than 11 years after seedling production, and when only 1 to 6 varieties remain from an original 80,000 to 100,000 seedlings in the evaluation program.

The newly implemented system of LAES regarding borer resistance also incorporates a method of quantifying adult moth production and varietal assessment targeted to the later stages of the *D. saccharalis* life cycle. Thus, not only are we able to predict the relative degree of resistance of varietal candidates to help the producer on an individual field basis, but we also can now predict the potential for reduction of pest populations on an area-wide basis. With this system in the LAES, information is provided for early assessment of future candidate varieties against the sugar cane borer, as well as resistance information on those lines used for breeding purposes before it is needed in the crossing program.

EFFECTS OF INTERACTIONS AMONG *PYTHIUM* SPECIES ON ROOT ROT IN SUGARCANE

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Several *Pythium* species are commonly isolated from roots of sugarcane plants grown in field soil. In pathology tests, only one species, *P. arrhenomanes*, caused severe root rot and growth reductions. To determine the effects of infection by multiple *Pythium* species on root rot and sugarcane growth, pathogenicity tests were conducted with single *Pythium* species and combinations of species, including *P. arrhenomanes*, *P. catenulatum*, *P. irregulare*, *P. spinosum*, and two unidentified *Pythium* species. *Pythium catenulatum* and the unidentified *Pythium* species did not cause root rot or growth reductions. *Pythium irregulare* and *P. spinosum* caused growth reductions without severe root rot symptoms. Combinations of *P. irregulare* and *P. spinosum* did not result in increased disease severity. Root rot caused by *P. arrhenomanes* was unaffected by combinations with other species. In experiments with field soils, *P. arrhenomanes* was generally isolated with highest frequency from plants that showed the most severe root rot and growth reductions.

CROSS EVALUATION USING A SMALL PROGENY TEST

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In most of the sugar cane breeding programs around the world, large numbers of seedlings have to be planted in order to obtain superior clones for release as new varieties. The improvement of seedlings populations by eliminating inferior progenies would increase the frequency of superior seedlings. The chances of obtaining superior varieties, therefore, would be significantly increased. This practice would greatly increase efficiency in making selections. The objectives of this study were to evaluate the progeny performance of the crosses with small numbers of seedlings per family and to evaluate the effectiveness of this progeny testing technique.

Crosses made in 1987/88 and 1988/89 flowering seasons at Canal Point, Florida were used for this study. Forty seedlings per cross from seed germination test of the regular seedling program. Selection rate, visual grade, mean stalk diameter of individual seedlings, and juice quality of bulked samples (one stalk from each seedling stool) were measured on each progeny. Visual grade was based on the general appearance of the seedling family. Five hundred to 1,500 seedlings from the same crosses, depending on the supply of stored fuzz, were planted in the regular seedling program in the following years. The selection rates from these crosses were used to measure the progeny performance in a comparison with those from the small sample progeny tests.

The progenies showed different levels of both general and specific combining abilities based on the mean values of the characters. Some parents or crosses produced higher progeny tests than from the regular seedling program. The relationship of selection rates between progeny tests and regular seedling program were very low.

The improvement of the general level of seedling populations could be more effective by increasing the means and variances of the seedling families with proven parents and proven crosses based on their general and specific combining abilities. Most of the characters are dependent on one another. If a selection index involving the consideration of several characters determined in a small sample could be developed, the efficiency of the seedling program could be greatly increased.

CHANGES IN THE SUCROSE CONTENT OF PARENT VARIETIES THROUGH FIVE CYCLES OF RECURRENT SELECTION IN LOUISIANA

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Improvements in sucrose content of Louisiana sugar cane varieites has been achieved through five cycles of recurrent selection beginning in the 1920's. Concurrently, sugar recoveries at the mills have increased dramatically and now exceed 100 kg per net ton of cane in a 7-9 month growing season. In the present study, the sucrose content, as well as the fiber content and yield of sugar per ton of cane, tons of cane per acre, and sugar per acre of 40 parental varieties most often used in crosses of five successive cycles of recurrent selection, were compared in the same first-ratoon crops. Sucrose content, yield of sugar per ton, tons cane per acre, and sugar per acre increased, as an average of both plant and firt ratoon cane, 31, 37, 54, and 108 percent, respectively, between parents used in Cycle 1, i.e., Co 281, Co 290, CP 807, POJ 213,, and POJ 234, and parents used in Cycle V, i.e., CP 70-321, CP 70-330, CP 72-356, CP 72-370, CP 74-383, CP 76-331, and CP 79-318. Little change was noted in fiber content between cycles.

Although there was considerable increase in the sucrose content of parents between Cycles I and V, the difference between each successive cycle was small, particularly in the latter cycles. This data would indicate that further progress in improving sucrose content of future varieties may be more difficult as sucrose content of parental varieites reaches an apparent plateau.

SUGAR CANE CULTIVAR RESPONSE TO CALCIUM SILICATE ON EVERGLADES HISTOSOLS

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Sugar cane grown on some Everglades Histosols has shown positive response to the application of calcium silicate slag. A site was selected with pervious history of response to slag. Four currently grown cultivars (CP70-1133, CP72-2086, CP74-2005, and CP80-1827) and a cultivar standard (CP72-1210) were established with two rates of slag (0, and 3 tons/acre) in order to evaluate response.

Results from two crops show that calcium silicate slag applied at 3 tons/acre increased sugar per acre on the average of 21 percent. Tons cane per acre (TPA) increases across cultivars ranged from 12 to 24 percent and 15 to 29 percent respectively for plant cane and first stubble crops. Higher TPA did not significantly affect juice quality. Production from four paris of adjacent commercial fields had 23.9 percent and 17.0 percent increases in TPA for plant cane and first stubble, respectively. Current response levels indicate that calcium silicate slag as a soil amendment is a feasible alternative for increasing crop yields.

HERBICIDE TREATMENTS FOR JOHNSONGRASS CONTROL IN FALLOW SUGAR CANE FIELDS

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Studies were conducted in Louisiana to evaluate various herbicide treatments for the control of johnsongrass in fallowed sugar cane fields. Fields of second-ratoon sugar cane were destroyed after harvest either in the fall or in the early spring by disking. Fields were subjected to periodic disking to destroy seedling weeds and vegetable propagules until the 1.8 m wide sugar cane beds were reformed in late-May or early-June. In the first study, preemergence herbicides applied broadcast to weed-free, clod-free beds within one week of their formation were evaluated. In a second study, the efficacy of several postemergence herbicides applied over-the-top to a heavy infestation of johnsongrass in the boot (flag leaf emerged) stage of development was evaluated.

In the first study, sulfomenturon applied to the soil surface at 31 g/ha provided the highest level (85 to 90 percent) of preemergence johnsongrass control 8 weeks after treatment. Johnsongrass control was similar (67 to 82 percent) for soil-surface applications of metribuzin and terbacil at 1.7 kg/ha and an incorporated application of trifluralin at 2.2 kg/ha followed by an application of atrazine to the soil surface at 2.2 kg/ha. Johnsongrass control with the sequential trifluralin plus atrazine treatment was significantly higher than with applications of either pendimethalin or prodiamine applied at 2.2 kg/ha in mixes with atrazine to the soil surface. All of the soil treatments provided effective preemergence control of small-seeded annual grass and broadleaf weeds including several morningglory species. The number of johnsongrass shoots 10 weeks after the replanting of sugar cane was significantly lower where preemergence herbicide treatments were followed with an application of glyphosate at 1 percent volume by volume to scattered stools of escaped johnsongrass.

In the second study, fluazifop at 0.21 kg/ha and quizalofop at 0.16 kg/ha were not as effective as glyphosate or glufosinate applied at 1.12 kg/ha, as evidenced by visual ratings of johnsongrass control 4 weeks after treatment and johnsongrass shoot counts made 10 weeks after sugar cane replanting.

The results of these studies suggest that herbicides can be used to effectively insure the rhizomatous johnsongrass and high levels of weed seeds are not present in fallowed fields at the time of replanting. Programs employing either early applications of sulfomenturon followed by spot application(s) of glyphosate to control escapes or multiple applications of glyphosate or glufosinate appear to be the most effective.

A SALINITY INDEX FOR SUGAR CANE IRRIGATION WATER IN THE LOWER RIO GRANDE VALLEY OF TEXAS

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Use of Class 3 river water to irrigate sugar cane in Texas brings with it potential salt problems. In this paper, Rio Grande River water is characterized and its effects on cane tonnage yields and sugar content are studied. An index is derived to compare year-to-year salinity variability.

MANUFACTURING ABSTRACTS

BAGASSE COMPOSTING AS A VOLUME REDUCTION TECHNOLOGY

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In most sugar processing operations, bagasse is the largest volume solid residual to be handled. The low unit weight of this material requires volume reduction to lower handling and transportation costs. Composting bagasse with filter press cake can reduce the volume of the co-mingled residuals by 60-70 percent. The resulting material is less expensive to transport, and handling and energy costs for both residuals can be reduced. The resulting compost can be land applied during favorable weather conditions and will return nutrients and organic matter to the fields. Composting reduces populations of weed seeds and disease organisms. Municipalities may be interested in obtaining bagasse to use as a carbon source for composting sewage sludge or filter press cake for composting yard waste.

EXPERIMENTAL STUDIES OF EVAPORATOR SCALE

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The problem of evaporator scale has been approached by various experimental techniques, including a completely automated pilot scale evaporator and devices inserted into factory evaporators. Each of these will be described, along with the results obtained from two crops in Louisiana. Much heavier scale formations occurs in later evaporator effects and all scale is predominantly inorganic. Composition data for the scale and the results of different treatments for scale removal will be presented.

ALTERNATIVE PRODUCTS FROM SUGAR PROCESSING

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The Louisiana Sugar Industry is dedicated to the production of a large volume, low price commodity, raw sugar. The industry is faced with a need to maximize yields from an essentially fixed agricultural base. This will undoubtedly mean a future shrinkage in the number of sugar mills

operating in the State. Although the future of the industry is not in doubt, the financial survival of individual mills may depend upon diversification of their product lines to non-traditional smaller volume, higher profitability products. In order to expand the traditional range of "by-products" available to a sugar producer, we have been working on developing two new process that can be adapted to Louisiana sugar mills.

Industrial polymers are a growing market opportunity. We have chosen two polymers as offering commercial potential to the Louisiana Industry, with operations that are partly adaptable to existing equipment in raw sugar mills. A process has been developed that can be used to produce controlled size dextrans suitable for several markets. Also well under development is a system that will produce a range of polymers capable of gelling in the presence of salts. These

polymers offer opportunity for the production of low volumes, high profit products. An outline of the individual processes and opportunities will be presented.

OPERATION OF CONTINUOUS PAN AND CRYSTALLIZERS AT ST. JAMES SUGAR COOPERATIVE

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The new low grade station at St. James Sugar Cooperative was installed in stages over a period of four years. The major equipment consist of a continuous pan and two vertical crystallizers. The low grade station operated as a completed unit starting the 1990 crop. No permanent staff was needed to operate the station. Good flow of the material by gravity through the vertical crystallizers to the continuous centrifuguals was achieved without the use of viscosity reducing chemicals. The molasses exhaustion attained was very good, with the average final molasses purity about three points below the target true purity.

EFFECT OF TEMPERATURE OF MACERATION WATER ON MILL EXTRACTION CHARACTERISTICS OF POLYSACCHARIDES AND LIGNINS

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A laboratory study was done on extracting the sugar cane rind (prepared in a pilot scale Tilby separator) with water over the temperature range 30 to 150 degrees C in a 1 liter stainless steel reactor. The extracts were analyzed for organic acids, sucrose, glucose, fructose, xylose, arabinose, and galactose prior to and after acid hydrolysis. Additional information on the extracted amounts and characteristics of the xyclose-based polysaccharides was obtained from SEC-MALLS (Size Exclusion Chromatography - MultiAngle Laser Light Scattering) analyses of the extracts. The effects are discussed with respect to choosing the temperature of the maceration water in milling and its effects on the amount of polysaccharides extracted and passed on to the mixed juice.

SEROLOGICAL DETERMINATION OF DEXTRAN LEVELS IN RAW SUGAR AND CRUSHER JUICE USING POLYCLONAL ANTISERA IN A TURBIDMETRIC ASSAY

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A turbidimetric assay utilizing polyclonal antisera was tested for its suitability to determine dextran levels in raw sugar samples from two Florida mills. During the 1990-91 crop, 237 sugar and 124 crusher juice samples were tested. For the sugar samples, the results of the serological turbidimetric assay were highly correlated to the results of the alcohol haze assay. For each of the individual mills r^7 values were 0.94 or greater; however, calculated regression lines for each of the mills were all different. For crusher juice samples, the turbidimetric assay was also highly correlated to the haze results, but the correlation was less than for the sugar samples. There were no significant differences in the regression lines for the crusher juice samples from the two mills.

Although not a substitute for the haze method, the serological assay has several advantages over the haze method that make it attractive for use as a screening method to evaluate the quality of incoming cane or outgoing sugar; these include its speed, simplicity, and low cost.

THE COST OF SUGAR FACTORY LOSSES

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Okeelanta Corporation
South Bay, Florida

The sucrose balance for a sugar factory is typically used by technical management and personnel in sugar companies to apportion recovery and losses on a percentage basis. From this same balance, the losses in terms of sugar and dollars may be derived and can provide valuable information for assessing the commitment and distribution of resources.

PROCEDURE TO FIT A FOURTH ROLL TO THE CONVENTIONAL (3) ROLL MILL

Jorge L. Lebron, Engineer
Cajun sugar Cooperative, Inc.
New Iberia, Louisiana

The adaptation of a fourth roll to the conventional (3) roll mill has become increasingly popular, every year, more sugar cane mills are converted to this system. Originally developed in South Africa in the early 1960's as a complement to the Donnelly or enclosed vertical chuté, it appeared in the U.S. Sugar Industry in Rio Grande Valley Sugar Growers in the year 1978, when one mill was fitted with the fourth roll. Management, mill engineers, and mill personnel have sensed a deep feeling of satisfaction, and very often pride, after adapting the fourth roll to the (3) roll mill. After listening with excitement about the benefits of the fourth roll, mill engineers ask themselves this question: How can I accomplish the adaptation of the fourth roll on my mills? At the beginning, many are skeptical that it can be done, but soon this attitude turns for an optimistic and realistic view, after sharing information with other engineers who already had converted their mills.

This paper will present the guidelines of the procedure to incorporate the fourth roll and related equipment to the conventional (3) roll mill, with emphasis in the modification to be done to the mill housings. The guidelines will bear incalculable significance to mill engineers that are in the process of performing or considering the adaptation of the fourth roll to the (3) roll mill and even to those that have given serious consideration to adapt the system.

FUEL CONSERVATION AND ENERGY MANAGEMENT CONCEPTS FOR THE SUGAR CANE MILLS

Charles M. Sallman
Modern Consultants, Inc.
Valparaison, IN

New ideas and energy management concepts to help Sugar Mill Managers are presented. Daily mill progress reports show relative costs for evaluation and projection during the operating season. This tool encourages employees to assist in making cost reductions.

VORTEX FLOW FILTRATION: TECHNOLOGY FOR HIGH SOLID FEEDS

R. Andrew Ratchford, Technical and Sales Manager
Membrex, Inc., Fairfield, New Jersey

Product clarification is of the most critical and difficult operations encountered in the purification of biologically produced products. These process operations which are found upstream in the purification train establish the upper range of product yield. Poor execution at any of these early stages can generate unacceptably low product yields, independent of well executed downstream purification steps. Contributing to the difficulty of these operations is the complex nature of the feeds which consist of both sugars and non-sugars.

Two operational problems have prevented the large scale adaptation of membrane processes in both laboratory and in pilot and production plants. First, membranes tend to foul, declining the filtration rate, requiring filter change. Fouling is usually related to non-specific absorption of materials from the feed onto the membrane surface. Fortunately, this can be controlled by selection of the proper membrane material and adjustment of the chemical environment of the feed. Second, the problem is due to a phenomenon called concentration polarization, which occurs due to the very nature of the filtration process. The solution filtered comes in contact with the membrane, and some of the solution passes through the filter pores. The material which does not pass exists at a higher local concentration right next to the membrane surface than in the rest of the solution. This build-up of concentration gradient occurs throughout the filtration process. This build-up behaves as a second membrane on top of the selected filter, that is, acting as a pre-filter.

Vortex Flow Filtration (VFF) technology provides a secondary flow profile, characterized by Taylor Vortices, to enhance filtration efficiency. Future developments might include "smart filters, filters inside reactors to absorb trace contaminants, filters for clean-up of toxic waste sites, filters for production lines to eliminate waste, and filters to clean up oil spills.

Filters for on line clarification of crushed cane juice is currently in operation in Florida and Louisiana.

In this presentation, we will discuss the principles of operation of several recently developed VFF systems and compare the peformance of the systems to other system technologies.

A NEW APPROACH TO MEASURING CANE LEVEL IN A CARRIER

Eduardo Samour, Assistant Chief Engineer
Sugar Cane Growers Co-op of Florida
Belle Glade, Florida

As technology becomes available to industry, and more sensors, control and "smart" devices are introduced, engineers are able to find simple and cost effective solutions to common problems. A particular case is the problem to measure the cane level in a conveyor, both before and after the cane knives, to insure a uniform matt of cane that traduces in a uniform mill feeding and better mill performance.

This paper describes the application of an ultrasonic sensor device, used during the 1990-91 crop at Sugar Cane Growers Cooperative of Florida. The sensor was used first as a detection for "gaps" in the cane level after a truck dumper, and then was used as sensing device for the speed control of a conveyor feeding one tandem. In both situations, this ultrasonic sensor proved to be reliable and much more simple than conventional mechanical devices. In addition, it can be connected directly to a PLC for "smart" control.

CONTINUOUS VERTICAL CRYSTALLIZERS FOR THE SUGAR INDUSTRY

Richard Smith
Silver Engineering Works
Aurora, Colorado

The result of several domestic installations, beet and cane, are presented. Some practical process considerations and the criteria for the selection of vertical crystallizers are discussed.

A PRACTICAL APPROACH TO ROLL ADJUSTMENT

Luis R. Zarraluqui
Sugar Cane Growers Coop.
Belle Glade, Florida

Thus far, the calculation of roll settings has been based on a mixture of scientific research and empirical knowledge. A proliferation of theoretical formulas and methods. ranging from the most complex and detailed, to the rational and simplified, is currently available. The figures obtained therefrom must then be modified, to take into account numerous physical conditions affecting mill feedability. Eventually, the different proportions among facts, assumptions, experience and judgement, allotted by each author at the hour of deciding roll settings, ended up taking the art into the realm or mystery and secrecy, making the prediction of settings belong increasingly in the sorcerer's domain, rather than in the engineer's.

The advent of two major innovations to the milling plant during the last two decades marked a revolution in mill feeding that unveiled forever the mystery surrounding roll adjustment. Roll arcing had been in use successfully since the early seventies, but heavy welding of roll teeth in the late seventies, and the addition of a fourth roll to the conventional three-roll mill in the early eighties, were milestones that shook a century-old stagnant technology to the roots, rendering the mill virtually choke-less thereafter.

In the wake of such commotion, it is now possible to follow a divestiture policy that will strip the adjustment of mill rolls of esoteric encumbrances, allowing us to get back to basics. This paper outlines, as a counterpart to theoretical calculation, a practical, trial-and-error, satisfaction guaranteed, procedure to adjust mill rolls, applicable in an easy, logical, step-by-step fashion. The discussion is limited, however, to bagasse mills, i.e., the second and successive units of a mill train. The first mill, being a cane mill in the fullest sense of the word, behaves distinctly, and a discussion on its adjustment warrants a separate treatment.

CONSTITUTION OF THE
AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

As Approved on June 21, 1991

ARTICLE I

Name, Object and Domicile

Section 1. The name of this Society shall be the American Society of Sugar Cane Technologists.

Section 2. The object of this society shall be the general study of the sugar industry in all its various branches and the dissemination of information to the members of the organization through meetings and publications.

Section 3. The domicile of the Society shall be at the office of the General Secretary-Treasurer (as described in Article IV, Section 1).

ARTICLE II

Divisions

The Society shall be composed of two divisions, the Louisiana Division and the Florida Division. Each division shall have its separate membership roster and separate officers and committees. Voting rights of active and honorary members shall be restricted to their respective divisions, except at the general annual and special meetings of the entire Society, hereinafter provided for, at which general meetings active and honorary members of both divisions shall have the right to vote. Officers and committee members shall be members of and serve the respective divisions from which elected or selected, except the General Secretary-Treasurer who shall serve the entire Society.

ARTICLE III

Membership and Dues

Section 1. There shall be five classes of members: Active, Associate, Honorary, Off-shore or Foreign, and Supporting.

Section 2. Active members shall be individuals residing in the continental United States actually engaged in the production of sugar cane or the manufacture of cane sugar, or research or education pertaining to the industry, including employees of any corporation, firm or other organization which is so engaged.

Section 3. Associate members shall be individuals not actively engaged in the production of sugar cane or the manufacture of cane sugar or research pertaining to the industry, but who may be interested in the objects of the Society.

Section 4. Honorary membership shall be conferred on any individual who has distinguished himself or herself in the sugar industry, and has been elected by a majority vote of the Joint Executive Committee. Honorary membership shall be exempt from dues and entitled to all the privileges of active membership. Each Division may have up to 15 living Honorary Members. In addition, there may be up to 5 living Honorary members assigned to the two Divisions jointly.

Section 5. Off-shore or foreign members shall be individuals not residing in the continental United States who may be interested in the objects of the Society.

Section 6. Supporting members shall be persons engaged in the manufacturing, production or distribution of equipment or supplies used in conjunction with production of sugar cane or cane sugar, or any corporation, firm or other organization engaged in the production of sugar cane or the manufacture of cane sugar, who may be interested in the objects of the Society.

Section 7. Applicants for new membership shall make written application to the Secretary-Treasurer of the respective divisions, endorsed by two members of the division, and such applications shall be acted upon by the division membership committee.

Section 8. Annual dues shall be as follows:

Active Membership ----------------------- $10.00
Associate Membership -------------------- $25.00
Honorary Membership --------------------- NONE
Off-shore or Foreign Membership ---------- $20.00
Supporting Membership ------------------- $50.00

Dues for each calendar year shall be paid not later than 3 months prior to the annual meeting of the member's division. New members shall pay the full amount of dues, irrespective of when they join.

Section 9. Dues shall be collected by each of the Division Secretary-Treasurers from the members in their respective divisions. Unless and until changed by action of the Joint Executive Committee, 50 percent of all dues collected shall be transmitted to the office of the General Secretary-Treasurer.

Section 10. Members in arrears for dues for more than a year will be dropped from membership after thirty days notice to this effect from the Secretary-Treasurer. Members thus dropped may be reinstated only after payment of back dues and assessments.

Section 11. Only active members of the Society whose dues are not in arrears and honorary members shall have the privilege of voting and holding office. Only members (all classes) shall have the privilege of speaking at meetings of the Society.

ARTICLE IV

General Secretary-Treasurer and Joint Executive Committee

Section 1. The General Secretary-Treasurer shall serve as Chief Administrative Officer of the Society and shall coordinate the activities of the divisions and the sections. He or she will serve as ex-officio Chairperson of the Joint Executive Committee and as General Chairperson of the General Society Meetings, and shall have such other duties as may be delegated to him or her by the Joint Executive Committee. The office of the General Secretary-Treasurer shall be the domicile of the Society.

Section 2. The Joint Executive Committee shall be composed of the members of the two division Executive Committees, and is vested with full authority to conduct the business and affairs of the Society.

ARTICLE V

Division Officers and Executive Committee

Section 1. The officers of each division of the Society shall be: a President, a First Vice-President, a Second Vice-President, a Secretary-Treasurer, and an Executive Committee composed of these officers and four other members, one from each section of the Division (as described in Section 3 of Article VII), one elected at large, and the President of the previous Executive Committee who shall serve as an Ex-Officio member of the Division Executive Committee.

Section 2. These officers, except Secretary-Treasurer, shall be nominated by a nominating committee and voted upon before the annual division meeting. Notices of such nominations shall be mailed to each member at least one month before such meeting. Ballots not received before the annually specified date will not be counted.

Section 3. The Secretary-Treasurer shall be appointed by and serve at the pleasure of the Division Executive Committee. The Secretary-Treasurer may not hold an elected office on the Executive Committee.

Section 4. The duties of these officers shall be such as usually pertain to such officers in similar societies.

Section 5. Each section as described in Article VII shall be represented in the offices of the President and Vice-President.

Section 6. The President, First Vice-President, and Second Vice-President of each Division shall not hold the same office for two consecutive years. Either Section Chairperson (as described in Section 3 of Article VII) may hold the same office for up to two consecutive years. The terms of the other officers shall be unlimited.

Section 7. The President shall be elected each year alternately from the two sections hereinafter provided for. In any given year, the Presidents of the two Divisions shall be nominated and elected from different sections. The President from the Louisiana Division for the year beginning February, 1970, shall be nominated and elected from the Agricultural Section. The president from the Florida Division for the year beginning February, 1970, shall be nominated and elected from the Manufacturing Section.

Section 8. Vacancies occurring between meetings shall be filled by the Division Executive Committee.

Section 9. The terms "year" and "consecutive year" as used in Articles V and VI shall be considered to be comprised of the elapsed time between one annual division meeting of the Society and the following annual division meeting of the Society.

ARTICLE VI

Division Committees

Section 1. The President of each division shall appoint a committee of three to serve as a Membership Committee. It will be the duty of this committee to pass upon applications for membership in the division and report to the Secretary-Treasurer.

Section 2. The President of each division shall appoint each year a committee of three to serve as a Nominating Committee. It will be the duty of the Secretary-Treasurer of the Division to notify all active and honorary members of the Division as to the personnel of this committee. It will be the duty of this committee to receive nominations and to prepare a list of nominees and mail this to each member of the Division at least a month before the annual meeting.

ARTICLE VII

Sections

Section 1. There shall be two sections of each Division, to be designated as:

1. Agricultural
2. Manufacturing

Section 2. Each active member shall designate whether he or she desires to be enrolled in the Agricultural Section or the Manufacturing Section.

Section 3. There shall be a Chairperson for each section of each Division who will be the member from that Section elected to the Executive Committee. It will be the duty of the Chairperson of a section to arrange the program for the annual Division meeting.

Section 4. The Executive Committee of each Division is empowered to elect one of their own number or to appoint another person to handle the details of printing, proof reading, etc., in connection with these programs and to authorize the Secretary-Treasurer to make whatever payments may be necessary for same.

ARTICLE VIII

Meetings

Section 1. The annual General Meeting of the members of the Society shall be held in June each year on a date and at a place to be determined, from time to time, by the Joint Executive Committee. At all meetings of the two Divisions of the Society, five percent of the active members shall constitute a quorum. The program for the annual meeting of the Society shall be arranged by the General Secretary-Treasurer in collaboration with the Joint Executive Committee.

Section 2. The annual meeting of the Louisiana Division shall be held in February of each year, at such time as the Executive Committee of the Division shall decide. The annual meeting of the Florida Division shall be held in September or October of each year, at such time as the Executive Committee of that Division shall decide. Special meetings of a Division may be called by the Executive Committee of such Division.

Section 3. Special meetings of a Section for the discussion of matters of particular interest to that Section may be called by the President upon request from the respective Chairperson of a Section.

Section 4. At Division meetings, 10 percent of the active division members and the President or a Vice-President shall constitute a quorum.

ARTICLE IX

Management

Section 1. The conduct and management of the affairs of the Society and of the Divisions including the direction of work of its special committees, shall be in the hands of the Joint Executive Committee and Division Executive Committees, respectively.

Section 2. The Joint Executive Committee shall represent this Society in conferences with the American Sugar Cane League, the Florida Sugar Cane League, or any other association, and may make any rules or conduct any business not in conflict with this Constitution.

Section 3. Four members of the Division Executive Committee shall constitute a quorum. The President, or in his or her absence one of the Vice-Presidents, shall chair this committee.

Section 4. Two members of each Division Executive Committee shall constitute a quorum of all members of the Joint Executive Committee. Each member of the Joint Executive Committee, except the General Secretary-Treasurer, shall be entitled to one vote on all matters voted upon by the Joint Executive Committee. In case of a tie vote, the General Secretary-Treasurer shall cast the deciding vote.

ARTICLE X

Publications

Section 1. The name of the official journal of the Society shall be the "Journal of the American Society of Sugar Cane Technologists." This Journal shall be published at least once per calendar year. All articles, whether volunteered or invited, shall be subject to review as described in Section 4 of Article X.

Section 2. The Managing Editor of the Journal of the American Society of Sugar Cane Technologists shall be a member of either the Florida or Louisiana Divisions; however, he or she shall not be a member of both Divisions. The Division affiliation of Managing Editors shall alternate between the Divisions from term to term with the normal term being three years, unless the Division responsible for nominating the new Managing Editor reports that it has no suitable candidate. The Managing Editor shall be appointed by the Joint Executive Committee no later than 6 months prior to the beginning of his or her term. A term will coincide with the date of the annual Joint Meeting of the Society. No one shall serve two consecutive terms unless there is no suitable candidate from either Division willing to replace the current Managing Editor. If the Managing Editor serves less than one year of his or her three-year term, another candidate is nominated by the same Division, approved by the other Division, and appointed by the General Secretary-Treasurer to a full three-year term. If the appointed Managing Editor serves more than one year but less than the full three-year term, the Technical Editor from the same Division will fill the unexpired term of the departed Managing Editor. In the event that the Technical Editor declines the nomination, the General Secretary-Treasurer will appoint a Managing Editor from the same Division to serve the unexpired term.

Section 3. The "Journal of the American Society of Sugar Cane Technologists" shall have two Technical Editors, which are an Agricultural Editor and a Manufacturing Editor. The Managing Editor shall appoint the Technical Editors for terms not to exceed his or her term of office. Any Technical Editor shall be a member of either the Louisiana or Florida Division. Each Division will be represented by one technical editor at all times unless the Executive Committee of one Division and the Managing Editor agree that there is no suitable candidate willing to serve from that Division.

Section 4. Any member or nonmember wishing to contribute to the Journal of the American Society of Sugar Cane Technologists shall submit his or her manuscript to the Managing Editor. The Managing Editor shall then assign the manuscript to the appropriate Technical Editor. The Technical Editor shall solicit peer reviews until, in the opinion of the Technical Editor, two responsible reviews have been obtained that either accept (with or without major or minor revision) or reject the manuscript. For articles accepted with major revision, it shall be the responsibility of the Technical Editor to decide if the authors have satisfactorily completed the major revision(s). The Technical Editor may solicit the opinion of the reviewers when making this decision. The Technical Editors shall not divulge the identity of any reviewer. The Managing Editor shall serve as Technical Editor of any manuscript which includes a Technical Editor as an author.

ARTICLE XI

Amendments

Section 1. Amendments to this Constitution may be made only at the annual meeting of the Society or at a special meeting of the Society. Written notices of such proposed amendments, accompanied by the signature of at least twenty (20) active or honorary members must be given to the General Secretary-Treasurer at least thirty (30) days before the date of the meeting, and he or she must notify each member of the proposed amendment before the date of the meeting.

ARTICLE XII

Dissolution

Section 1. All members must receive notification from the General Secretary-Treasurer of any meeting called for the purpose of terminating the Society at least thirty (30) days prior to the date of the meeting. After all members have been properly notified, this organization may be terminated at any time, at any regular or special meeting called for that purpose, by an affirmative vote of two-thirds of the total honorary and active members in good standing present at the meeting. Thereupon, the organization shall be dissolved by such legal proceedings as are provided by law. Upon dissolution of the Joint Society, its assets will be divided equally between the two Divisions of the Society. Dissolution of the Joint Society will not be cause for automatic dissolution of either Division. Upon dissolution of either Division, its assets will be divided in accordance with the wishes of its members and in conformity with existing IRS regulations and other laws applicable at the time of dissolution.

ARTICLE XIII

Assets

Section 1. No member shall have any vested right, interest or privilege of, in, or to the assets, functions, affairs or franchises of the organization; nor any right, interest or privilege which may be transferable or inheritable.

AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS
EDITORIAL POLICY

Nature of papers to be published:

Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

Frequency of publication:

The Journal will appear at least once a year. At the direction of the Joint Executive Committee, the Journal may appear more frequently. Contributed papers not presented at a meeting may be reviewed, edited, and published if the editorial criteria are met.

Editorial Committee:

The Editorial Committee shall be composed of the managing editor, technical editor for the Agricultural Section and technical editor for the Processing Section.

The Editorial Committee shall regulate the Journal content and assure its quality. They are charged with the authority necessary to achieve these goals. The Editorial Committee shall determine broad policy. Each editor will serve for three years; he may at the Joint Executive Committee's discretion, serve beyond the expiration of his term.

Handling of manuscripts:

Four copies of each manuscript are submitted to the managing editor. Manuscripts received by the managing editor will be assigned a registration number determined serially by the date of receipt. The managing editor writes to the one who submitted the paper to inform the author of the receipt of the paper, the registration number which must be used in all correspondence regarding it, and the page cost of publishing.

The technical editor receives from the managing editor all papers whose subject matter falls in his "area." He obtains at least two views for each paper from qualified persons. The identities of reviewers must not be revealed to each other nor to the author during the review process. Instructions sent with the papers emphasize the necessity for promptness as well as thoroughness in making the review. Page charges will be assessed for the entire manuscript for non-members. Members will be assessed for those pages in excess of ten (10) double spaced pic typed pages of 8 1/2 x 11" dimension with one (1) inch margins.

When a paper is returned by a reviewer, the technical editor evaluates the paper and the recommendations of the reviewers. If the paper as received is recommended by two reviewers for publication in the Journal, it is sent to the managing editor.

If major revisions are recommended, the technical editor sends the paper to the author for this purpose, along with anonymous copies of reviewers' recommendations. When the paper is returned to the technical editor, he will judge the adequacy of the revision and should send the paper back to any reviewer who requested major changes, for his further review. When the paper has been revised satisfactorily, it is sent to the managing editor for publishing. A paper sent to its author for revision and held more than 6 months will be given a new date of receipt when returned. This date will determine the priority of publication of the paper.

A paper rejected by one reviewer may be sent to additional reviewers until two reviewers either accept or reject the paper.

If a paper is judged by two or more reviewers as not acceptable for the Journal, the technical editor returns it to the author along with a summary of the reasons given by the reviewers for the rejection. The registration form for the paper is filled out and returned to the managing editor along with copies of the reviewers' statements and a copy of the technical editor's transmittal letter to the author. The reviewers' statements should not be forwarded to the author in this instance.

The names of all reviewers must be shown on the registration form.

After the review process is completed, each accepted paper is read by the technical editor to correct typographical, grammatical, and style errors and to improve the writing where this seems possible and appropriate, with special care not to change the meaning. Instructions for the printer are inserted as needed. The papers are sent by the technical editor to the managing editor who notifies the authors of this fact and of the probable dates of publication.

Preparation of papers for publication:

Papers sent by the technical editor to the managing editor are prepared for printing according to their dates of original submittal and final approval and according to the space available in the next issue of the Journal.

The paper is printed in the proper form of reproduction, and proofs are sent to the authors for final review. When the proofs are returned, all necessary corrections are made prior to reproduction.

The drawings and photographs for the figures in the paper are "scaled" according to their dimensions, the size of lettering, and other factors. They are then sent to the printer for camera work. Proofs of the illustrations are sent to the authors. Any changes requested at this stage would be expensive and authors will be expected to pay the cost of such changes.

The author will be notified at the appropriate time that he may order reprints at cost.

Reprinting in trade journals has the approval of the Editorial Committee provided; a)no article is reprinted before being accepted by the Journal; b)credit is given the author, his institution and the ASSCT; and c)permission of the author has been obtained. Summaries, condensations, or portions may be printed in advance of Journal publication provided the approval of the Editorial Committee has been obtained.

RULES FOR PREPARING PAPERS TO BE PRINTED IN THE JOURNAL OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

Format

Unless the nature of the manuscript prevents, it should include the following sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION, CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized. Scientific names shall be italicized.

All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. Exactness in reproduction can be insured if electronic copies of the final versions of manuscripts are submitted. Potential authors are encouraged to contact the managing editor for specifics regarding software and formatting software to achieve ease of electronic transfer.

Authorship

Name of the author(s), institution or organization with which he is associated, and the location should follow the title of the paper.

Abstract

The abstract should be placed at the beginning of the manuscript, immediately following the author's name, organization and location.

Tables

Number the tables consecutively and refer to them in the text as Table 1, Table 2, etc. Each table must have a heading or caption. Capitalize only the initial word and proper names in table headings. Headings and text of tables should be single spaced. Use TAB function rather than SPACE BAR to separate columns of a table. Each table should be on a separate sheet.

Figures

Number the figures consecutively and refer to them in the text as Figure 1, Figure 2, etc. Each figure must have a legend. Figures must be of sufficient quality to reproduce legibly.

Drawings & Photographs

Drawings and photographs must be provided separately from the text of the manuscript and identified on the back of each. Type figure numbers and legends on separate pieces of paper with proper identification. Drawings and photographs should be of sufficient quality that they will reproduce legibly.

Reference Citations

The heading for the literature cited should be REFERENCES. References should be arranged such that the literature cited will be numbered consecutively and placed in alphabetical order according to the surname of the senior author. In the text, references to literature cited can be made by number or name of author and number from list of references. (See example.) Do not use capital letters in the titles of such articles except in initial words

and proper names, but capitalize words in the titles of the periodicals or books.
Rev. 5/92

Format Example

EVALUATION OF SUGARCANE CHARACTERISTICS FOR MECHANICAL HARVESTING IN FLORIDA

J. E. Clayton and B. R. Eiland
Agricultural Engineers, SEA, USDA, Belle Glade, Florida

J. D. Miller and P. Tai
Research Geneticists, SEA, USDA, and Canal Point, Florida

ABSTRACT

INTRODUCTION

MATERIALS AND METHODS

RESULTS

Table 1. Varietal characteristics of nine varieties of sugarcane over three-year period at Belle Glade, Florida.

Figure 1. Relative size of membrane pores.

DISCUSSION

CONCLUSIONS

ACKNOWLEDGMENTS

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JOURNAL

American Society of Sugar Cane Technologists

Volume 13

Florida and Louisiana Divisions

September, 1993

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PRESIDENT'S MESSAGE
FLORIDA DIVISION

Bill Kramer

It gives me great pleasure to welcome you to the Twenty-Second Annual Joint Meeting of the Louisiana and Florida Divisions of the American Society of Sugar Cane Technologists. St. Augustine is a wonderful place for us to share our thoughts on the domestic sugar industry. I hope you will take the time to explore this historic Florida city where many believe Ponce de Leon first brought sugar cane to North America in the year 1512.

The Florida sugar industry has gone through many phases since 1512. I'm happy to inform you that our most recent year experienced a good production phase. Florida was blessed with good weather, featuring mild temperatures without a freeze and enough rainfall to bring us out of a drought situation. There was even enough rainfall to create reserves for our irrigation needs. Mother Nature's kindness certainly contributed to our excellent year, and the industry contributed by continuing to adapt to changing times.

One sign of the adaption is that for the first time, over 50 percent of Florida's crop was harvested mechanically, indicating that progress is being made in the use of mechanical harvesters on the soft muck soils. The Florida sugar industry produced 1,833,362 short tons of sugar raw value from 16,110,000 tons of sugar cane grown on 430,000 acres in Palm Beach, Hendry, Glades, and Martin counties. Overall, Florida growers produced 38 tons of sugar cane and 4.3 tons of sugar per acre.

The excellent crop helped the Florida sugar industry face poorer market conditions and resist an all-out attack on our industry by eco-zealots. Those zealots place little value on the economic contributions of the sugar industry or on the lives it impacts in a positive manner. Our legal expenses have reached staggering proportions-proving our innocence has become an all-too-common facet of our business lives.

High profile charges of pollution are easy to make, and difficult to disprove in an arena of publicity-oriented environmental groups and vote-chasing politicians. Stormwater runoff is the new pollution battleground of the 1990's. State and federal regulators are using our industry in Florida to set the precedent for creating a numerical phosphorous standard for Class III waters. Scientifically, no one knows what the numerical value should be, yet the state and federal regulators have set a phosphorous standard which is only half the content found in state-wide average rainfall. This standard could not be met by the most popular sparkling bottled waters such as Perrier, LaCroix, and Evian.

This issue has created an all-out public relations war between residents who live and work in the sugar producing areas and the environmentalist dominated regulators. We will continue fighting for our livelihoods through the courts, continue trying to educate the public through an information program, and continue fostering scientific research on environmental matters. We must emphasize the role of sound scientific research in shaping public policy.

As an industry, we are committed to helping protect the Everglades and to preserving farming in the Everglades Agricultural Area. Fortunately our industry has been far-sighted enough to have hired Duke University Wetland Center to conduct experimental (cause and effect) research in the Everglades with the goal of maintaining biotic diversity in wetland communities. Duke is in its third year of a five-year research plan. We are hopeful that this work will be allowed to be completed prior to full-scale implementation of the state and federal governments' Everglades settlement agreement, which will cause untold harm to agriculture in the Everglades Agricultural Area. The plan, if implemented, may even cause harm to the Everglades National Park because it fails to adequately recognize the dominant role that hydroperiod plays in a habitat creation and preservation.

If the regulators let scientific research shape policy, then I'm confident our Florida industry will continue to be a vital and prosperous one. But if they let political expediency continue to shape policy, then the industry's battle for survival will be long and expensive. Only time will tell, but rest assured the Florida industry will devote the resources necessary to survive.

That's the bad news on the environmental front. The good news is we have again survived a challenge to our pre-harvest open-burning program. More than twenty years of data from our extensive private air monitoring network proved to be invaluable as new regulations were being formulated. The data proved that pre-harvest burning is not a health threat and only creates a nuisance when climatic conditions are unfavorable. By working with the state regulators to develop and implement burning restrictions which consider wind speed and direction, we eliminated over 60 percent of the complaints of nuisance ash fallout by the urban community. As the urban population continues to encroach upon our farming area, it becomes even more important to listen to our neighbors' concerns and to find ways to deal with them. Yes, the new restriction caused some hardships and changes in harvesting schedules, but all within liveable, profitable constraints. Slight inconveniences are far more palatable than the thought of losing the burning program forever. We are proud of the success of this program which has balanced the industry's needs, the public's concerns, and the regulator's responsibilities.

Turning attention away from the local scene and to the national picture, The General Agreement on Tariff and Trade (GATT) and the pending North American Free Trade Agreement (NAFTA) still fill us with concern. We are concerned that our government will trade away sugar, cotton and rice as well as other Section 22 commodities for concessions in other areas. We have had to be ever watchful and aggressive with our own U.S. negotiators during these talks. Ironically, the Europeans have continued to be our saviors in preventing a bad agreement from taking place. Our industry stands ready to compete in a world of fair trade but resists being sacrificed while other producers outside the United States retain their extensive subsidies. You will be hearing more about free trade in the world market place, about how a post-Castro Cuba may fit into world trade, and about the impacts of these free trade agreements later in today's program.

If the way the U.S. Department of Agriculture administers the sugar program is any indication, we can safely say that the Bush administration is not sugar's best friend. Through micro-management, the U.S. Department of Agriculture has caused domestic raw sugar prices to fall to a five year low. The Department has failed to set a Market Stabilization Price (MSP) for the last two years. By setting a large import quota that allowed the importation of excessive raw sugars, the Department caused the market to be depressed to a point near the Florida forfeiture level. Even with depressed producer and refiner prices, the cost consumers pay for sugar-containing products has not dropped; as a matter of fact, the Consumer Price Index for ten categories containing sugar has increased by 23 percent during the 1st five years. This is another example of just who benefits at the farmer's expense...the big food manufacturers.

Ending on a good note, I'm proud to report consumption of sugar in the United States is at an eight-year high. Through the efforts of the Sugar Association, the good news about sugar has spread. Several prestigious publications such as the Mayo Clinic Newsletter have reported the fact that sugar is not the dietary villain it was once made out to be. Consumers now have more concerns about consumption of fats rather than sugar, partially due to the recent Food & Drug Administration's reports.

Sugar will continue to be viewed as the Gold Standard for sweetness in the sweetener industry, but competition will continue to be fierce as Nutrasweet's patent expires and improvements are made in the crystalline fructose product. We must continue to be vigilant in looking for new markets for our products through innovative research techniques. Our work as scientists, growers, millers, and business persons helps produce a quality product in an efficient industry. We will have to continue to find ways to do better in order to survive in today's world.

As you can see, we make our living in a climate full of challenges at all levels. There is an old saying that "if it were easy, then anybody could do it." Certainly the sugar business is not for just anybody. I salute the intelligence, hard work and perseverance of the ASSCT members. I'm proud to be associated with people who work hard to do difficult things under difficult, intense circumstances.

On behalf of the Florida division, I wish everyone a relaxed, enjoyable learning experience during our Joint Annual Meeting, and a safe journey home after our program concludes.

PRESIDENT'S MESSAGE
LOUISIANA DIVISION

Stephen Guillot

On behalf of the membership of the Louisiana Division of the American Society of Sugar Cane Technologists, I would like to thank the Florida Division for hosting this 22nd annual joint meeting in St. Augustine, Florida.

As reported last year, the 1990 sugar cane crop in Louisiana was drastically affected by the December 22 freeze of 1989. In some areas as much as 80 percent of the crop was destroyed. There were only 237,000 acres of sugar cane produced for sugar and seed in 1990, and yielded only 4,648,281 tons of cane. The average sugar per ton was 191 pounds and a total of only 443,000 tons of sugar was produced. This was a severe blow to the economy of the Louisiana sugar industry.

In 1991, the potential for a bumper crop was the talk of the industry. About 55 percent of the Louisiana cane acreage was in plant-cane and at the start of the growing season it looked very promising. However, shortly after the first of January, 1991 adversities started mounting. Excessive rainfall started during January and continued constantly through July. Many acres of sugar cane were flooded and remained under water for over four weeks. Cane which was not killed outright by the flood was decimated by nutria rats and/or yields dramatically reduced. Total rainfall for the year 1991 varied from 89 to 124 inches within the sugar belt. Most cultural practices were interrupted and in some areas fertilizer had to be applied by air. Some areas were able to cultivate early in the season; however, little or no lay-by cultivation was done which dramatically affected harvest efficiency. Our weed control program was, for the most part, very ineffective. During April and May which is normally dry when cane does most of its tillering, we experienced our heaviest rainfall. As a result, very little tillering took place. Further, due to the excessive rains there was a tremendous early build up of the sugar cane borer which played havoc with the crop. In some areas, as many as five applications (cost of over $60/acre) of insecticides were made and still yield and quality were seriously affected.

The rains did let up long enough during the planting season and most fields were planted. The 1991 harvest began in early October with several mills still feeling optimistic and predicting a good crop. During the first two weeks of harvest, yields of stubble cane were fair and sugar recovery was good with cane treated with the chemical ripener, Polado. During the third week of harvest, the area again experienced rain and much of the remaining cane was harvested under wet field conditions.

To make matters worse, a killing freeze occurred on November 4 that caused some damage to stalks primarily in the northern part of the state. However, on November 6 through 11, another blast of frigid air brought sub-freezing conditions to the entire state. Temperatures dipped to as low as 23°F at Bunkie to 26°F at Houma. Most cane in the north and western areas of the state showed considerable damage to stalks. Within two weeks, we started to see post-freeze deterioration of the crop. Yield in tons of cane per acre soon began to drop due to dehydration and lower topping of stalks. Further, sugar per ton began to drop as well. Many mills, that started in early October with hopes of a good crop, actually concluded the harvest during the first week of December with little or no impact from the freezes. Considering the year, the average recovery of sugar per ton was still a respectable 189 lbs for the crop. However, those mills still processing during Christmas week experienced some reduction in sugar yields due to the freeze and wet weather.

Even after all the adversities, the 1991 crop was not a total disaster. Louisiana had 347,000 acres that yielded 7,945,000 tons of cane. At first glance, you would say that this was one of Louisiana's best crops considering the increased acres and a total yield of 750,000 tons of sugar. However, this was a costly crop to produce and thus added to the financial woes of most producers.

Many Louisiana sugar cane growers are farming under severe financial stress for 1992 even though there might be a record area planted to sugar cane of over 380,000 acres. Several factors contributed to this condition besides the freeze of 1990 and the floods and early freezes of 1991. In most cases, land rent is fixed at 20 percent of gross income and does not vary with adverse conditions. Even though as a grower I have reduced my expenses as much as practical, the rent must still be paid at the 20 percent rate. Further, mandatory workers compensation insurance has increased this year form 11.7 percent to 15.7 percent of annual payroll. Also, mandatory unemployment compensation insurance can be up to 5.6 percent. The employer also contributes 7.65 percent of payroll to social security deposit for employees. Excluding any hospitalization insurance, the average grower is having to pay 28 percent above his actual payroll wages to work his employees. Further, herbicide prices are about 10 percent above last year and although interest rates have declined about 1.5 percent since last year, due to the deterioration of the financial position of most growers, their loans have been reclassified resulting in most growers having to pay at higher rates. As a result, most of these growers will be paying the same interest rates as last year on both production and equipment loans.

With each passing year, the Louisiana cane farmer has to be more and more conservative and be a better manager in order to survive. Our life blood continues to be research that gives us new varieties, cultural practices, herbicides, insecticides, etc. We are particularly grateful to the researchers from the USDA-ARS, Sugarcane Research Unit, the Louisiana Agricultural Experiment Station of the Louisiana State University Agricultural Center, and the American Sugar Cane League, as well as the LSU Cooperative Extension Service, who makes the information generated by research available to the growers and processors on a timely bases.

Two new varieties have been released for commercial production during the past three years. In 1990, LCP 82-89 was released and in 1991 LHO 83-153 was released. It is hoped that these varieties will have a positive financial impact on the Louisiana Sugar Industry.

Several years ago, through a cooperative venture of the Louisiana Farm Bureau and the American Sugar Cane League, a voluntary check-off program was established for the purpose of funding necessary research projects. Approximately $310,000 was allocated for fiscal year 1992 to fund research projects ranging from agronomic concerns to work dedicated to addressing needs in processing. This research has greatly benefited the industry. Politically it is important that we concern ourselves with the General Agreement on Tariffs and Trade (GATT) discussions. Very little progress has been made on these talks during the past several months. We are appreciative of our Congressional Delegation for the interest they have taken in protecting the survival of the domestic sugar industry. It is important that all segments of the sugar producing areas of the United States be united and work together in promoting and protecting our sugar industry.

Over the past several years, there has been a growing concern over environmental issues. The public is getting more concerned over the materials we are using for pest control. During last summer many complaints were filed over fish-kills blamed on the use of azinphos methyl (Guthion) for control of the sugarcane borer. At one point, the label for this insecticide was removed from the market. It is very important that the grower read labels carefully and apply herbicides and pesticides at recommended rates and only when needed.

The processors are also having to modify their plants and their operations to comply with EPA regulations. Much is being done to control plant emissions and to improve the quality of water being discharged from the mills. Several mills have installed oxidation ponds, aerators, and are recycling their wash and condenser water. Continuous improvements are being made by both growers and processors to help maintain the quality of our environment.

The Louisiana sugar cane industry has a reputation of being one who can overcome most adversities. This year should be a true test of its stamina. Considering the past two years, the industry is due for a good year. With dedication and hard work and God's help, the Louisiana sugar industry will continue to grow and prosper.

PEER REFEREED JOURNAL ARTICLES

SUGARCANE YIELDS FROM PLANT AND RATOON SOURCES OF SEED CANE

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ABSTRACT

Sugarcane (a complex hybrid of *Saccharum* spp.) growers in Florida use seed cane primarily from plant rather than ratoon crops. Growers would benefit by using ratoon seed cane if doing so would not reduce yields. Using seed cane from ratoon fields could ease logistical constraints and enhance the use of disease-free seed cane. The objective of this study was to compare yields of several sugarcane cultivars grown from three sources of seed cane, the plant, first-ratoon, and second-ratoon crops. We conducted three field experiments from 1985 through 1989. Plant-crop seed cane came from fields planted the previous December or January, and ratoon seed cane came from fields harvested the previous March. In two of the three experiments, there were no differences in cane yields due to crop of seed cane. In the other experiment, seed cane from the second-ratoon crop yielded more cane per acre than seed cane from the plant crop. Sugarcane growers in Florida should expect at least equal cane yields after planting first- or second-ratoon seed cane compared to plant-crop seed cane. Also, a lack of significant crop of seed cane x cultivar interactions in this study indicates that growers can expect consistent yields from plant- through second-ratoon crop seed cane of most commercial cultivars.

INTRODUCTION

The plant through the second-ratoon crops comprise more than 81% of Florida's sugarcane acreage. The plant and first-ratoon crops constitute about 58% and second-ratoon makes up about 23% of the total cane acreage (3). Most Florida sugarcane growers probably use plant-cane fields as a seed source because they expect that doing so will result in better emergence and higher yields in their newly planted fields. The objective of this field study was to compare cane yields of seed cane from the plant, first-ratoon, and second-ratoon crops of various sugarcane cultivars.

We showed earlier in greenhouse experiments, that for most cultivars, emergence of first- or second-ratoon seed cane at least equaled the emergence of plant-crop seed cane (4). Growers would realize several benefits if this equal emergence resulted in at least equal yields. At times, growers choose a seed cane source because it is the closest plant-crop field to where they are planting. By also using ratoon sources, growers would reduce transportation distances of seed cane, and would be more likely to find available seed cane of desirable cultivars.

A common practice in Florida is to plant sugarcane successively. In the successive planting system, growers must wait to begin land preparation until they have completed harvesting the final-ratoon sugarcane crop (often second ratoon). Time is often a major constraint in successive planting in Florida where the harvest begins in mid October. Under the fallow planting system, growers may plant as early as September. By using second-ratoon seed cane for their September and October fallow plantings, growers could then successively plant the fields from which they had obtained their seed cane. This would allow growers to begin their successive planting earlier.

Some growers in Florida control ratoon stunting disease (RSD) (*Clavibacter xyli* subsp. *xyli* Davis) by planting seed cane that is free of the disease. To obtain such RSD-free seed cane, growers submerge infected cane in tanks of hot water. Once treated successfully, the cane remains free of RSD unless it contacts the disease organism. Such contact usually occurs from contaminated cane knives or machine blades. Growers who use only plant cane as seed must heat treat seed cane each year to continue planting RSD-free seed cane. However, by using ratoon seed cane, growers could heat treat a seed source once and use it for seed cane from its plant, first-ratoon, and second-ratoon crops provided they use knives not contaminated with RSD when they cut the seed cane.

MATERIALS AND METHODS

From October 1985 through February 1989, we conducted three field experiments. We planted the first experiment (Experiment 1) on 1 Oct. 1985 at New Hope Sugar Cooperative, near Pahokee, Florida on a Pahokee muck soil (euic, hyperthermic Lithic Medisaprist). We harvested two crops from this planting, plant cane and first ratoon. We planted two more experiments at the USDA Sugarcane Field Station located at Canal Point, Florida on a Torry muck soil (euic, hyperthermic Typic Medisaprist). One was planted 17 March 1987 (Experiment 2) and harvested as plant cane and first ratoon. The final experiment (Experiment 3) was planted 10 Dec. 1987 and harvested only as plant cane.

In all three experiments, we planted 2 lines of seed cane with the top of one stalk placed in the furrow by the bottom of the adjacent stalk. Plots were single, 10-ft long rows in the first two experiments and single, 12-ft long rows in the third experiment. Rows were 5 ft apart in all experiments. Border rows surrounded the outside of each experiment, but no borders separated individual plots from each other. Experiments 1 and 3 had 4 replications and the second experiment had 5 replications.

We planted all three experiments in randomized-complete block designs. Analysis of Experiment 1 was as a 10 x 3 factorial with 10 cultivars and 3 crops of seed cane. Since we harvested this experiment once as plant cane and later as first ratoon, we evaluated harvest as a split plot in time (5). Experiment 2 was analyzed as a randomized complete block with one treatment (crop of seed cane), and harvests split in time as in Experiment 1. Experiment 3 was a 3 x 3 factorial (cultivars x crops of seed cane) with one harvest. In all three experiments, we sought significant differences at $P = 0.10$ with the LSD. We calculated LSD's and used them for all treatment comparisons regardless of significance of overall F values (2).

We planted 10 cultivars in Experiment 1 (New Hope Sugar Cooperative): CP 65-357, CP 70-1133, CP 70-1527, CP 72-1210, CP 72-2086, CP 73-1547, CP 74-2005, CP 75-1082, CP 75-1553, and CP 75-1632. To estimate yields, we counted total millable stalks in each plot and later weighed a seven-stalk sample to estimate stalk weight. The product of stalk weight by the number of stalks per plot estimated the tons cane per acre of each plot. In the plant crop, we counted stalks on 17 Sept. 1986 and in first ratoon on 19 Aug. 1987. We cut and weighed samples on 18 Sept. 1986 in the plant crop and 2 Oct. 1987 in first ratoon.

For Experiment 1, the seed cane sources had been planted in the field as follows: plant crop, 19 Dec. 1984; first ratoon, 1 Dec. 1983; and second ratoon, 10 Nov. 1982. For Experiment 2, the plant-crop seed cane had been planted 3 Jan. 1986, first-ratoon seed cane on 19 Dec, 1984, and second-ratoon seed cane on 1 Dec. 1983. For Experiment 3, the plant-crop seed cane had been planted 30 Jan. 1987, the first-ratoon seed cane 3 Jan. 1986, and the second-ratoon seed cane 19 Dec. 1984. We obtained ratoon seed cane from fields that had been harvested the previous March in all three experiments. Thus, in each experiment, the ratoon seed cane had 1-2 months less time for regrowth than the entire growth period of the plant-crop seed cane. We did not feel that this influenced results because sugarcane normally grows slowly in January and February in Florida due to cool weather. Also, temperatures dropped to 33° F on 21 and 22 Jan. 1985, and temperatures dropped below freezing (30° F) on 29 Jan. 1986.

In Experiments 2 and 3, each plot was cut by hand and weighed with a tractor-mounted weighing device. We estimated tons of cane per acre directly from these weights. The plant-crop harvest of Experiment 2 took place 3 Dec. 1987 and the first-ratoon on 18 Jan. 1989. Only one cultivar, CP 72-1210, was planted in this experiment. Experiment 3 was harvested in the plant crop 25 Jan. 1989. We also collected samples of 10 stalks from each plot on 25 Jan. 1989 to determine stalk weight and lbs sugar per ton of cane by the Winter Carp Geerlig formula (1). This experiment contained three cultivars, CP 72-1210, CP 74-2005, and CP 78-1247.

RESULTS AND DISCUSSION

Experiment 1

Although we were primarily concerned with the treatment effects on yield, we also examined two components of yield, stalk number and stalk weight. Table 1 lists F values and their probabilities for the effects of the treatments on cane yield, stalk number, and stalk weight. Seed-cane crop, averaged over the 10 cultivars and both harvests, had an F value significant at $P = 0.15$ for cane yield. Crop of seed cane, either alone or interacting with other sources of variation, had no significant effect on stalk weight or stalk number at $P < 0.15$. Thus, crop of seed cane did not account for large significant differences in yield or its components. Also, the cane-yield F value for cultivar was more than five times greater than the F value for crop of seed cane. This suggests that the magnitudes of the differences in cane yields due to crop of seed cane were small compared to differences caused by cultivar.

Table 1. F values and their probabilities from analyses of variance for cane yield, stalk weight, and stalk number from an experiment planted in 1985 at New Hope Sugar Cooperative (Experiment 1).

Source of Variation	Cane yield		Stalk weight		Stalk number	
	F	P > F	F	P > F	F	P > F
Rep	0.12	0.95	1.13	0.34	0.23	<0.01
Cultivar (A)	11.76	<0.01	7.48	<0.01	18.29	<0.01
Crop of seed cane (B)	1.95	0.15	0.53	0.59	1.60	0.21
A x B	1.17	0.30	1.34	0.18	1.09	0.37
Harvest (C)	5.11	0.03	24.80	<0.01	83.69	<0.01
A x C	4.48	<0.01	1.49	0.16	2.73	0.01
B x C	1.71	0.19	0.75	0.47	0.84	0.43
A x B x C	1.44	0.13	0.93	0.54	1.30	0.21

Still, the overall F value for crop of seed cane was significant at $P = 0.15$. We could ignore this level of significance because it is higher than our stated level of $P = 0.10$, which is already higher than that of most studies. However, to make a stronger case for using seed cane from ratoon fields, we felt that $P = 0.15$ was sufficiently close to $P = 0.10$ to warrant more detailed examination. Table 2 shows the cane yields of each crop of seed cane treatment. The cane yields of seed cane from the plant and first-ratoon crops did not differ significantly. However, second-ratoon seed cane yielded significantly more cane per acre than seed cane from the plant crop. Second-ratoon seed cane yielded more than first-ratoon seed cane, although the difference was not significant ($P = 0.14$).

Table 2. Cane yields of ten sugarcane cultivars planted at New Hope Sugar Cooperative (Experiment 1) with seed cane from the plant, first-ratoon, and second-ratoon crops.

Cultivar	Crop of seed cane			
	Plant cane	First ratoon	Second ratoon	Mean[1]
	Tons cane per acre			
CP 70-1133	92.3	85.0	99.3	92.2
CP 72-1210	86.7	82.7	100.3	89.9
CP 70-1527	54.3	76.5	72.7	67.8
CP 75-1553	60.4	74.1	60.0	64.8
CP 65-357	73.0	51.3	67.6	64.0
CP 75-1632	55.2	73.5	53.8	60.8
CP 72-2086	45.3	47.3	71.4	54.7
CP 75-1082	45.6	57.0	46.0	49.6
CP 74-2005	43.4	31.3	48.7	41.1
CP 73-1547	38.7	32.4	50.5	40.5
Mean[2]	59.5	61.1	67.0	62.5

[1] LSD (P = 0.10) for determining differences among cultivar means is 12.2 tons cane per acre.

[2] LSD (P = 0.10) for determining differences among crops of seed cane is 6.7 tons cane per acre and for cultivar x crop of seed cane interactions is 20.9 tons cane per acre.

Upon initiating this experiment, we hoped to determine that ratoon seed cane would produce yields not less than those of seed cane from the plant crop. We did not expect second-ratoon seed cane to produce yields greater than the yields from plant-crop seed cane. In retrospect, we considered that ratoon cane may have more buds per unit length than plant-crop seed cane. Thus, planting equal lengths of cane would be advantageous to ratoon seed cane, because it would have more buds than the equal length of plant-crop seed cane. To test this hypothesis, we counted the number of buds per ft of stalk and reported the results in Figure 1. Second-ratoon stalks had more buds per ft than plant-crop or first-ratoon stalks which had a similar number of buds per ft of stalk.

Table 2 also shows the yield of each cultivar x crop of seed cane treatment. The overall F value for the crop of seed cane x cultivar interaction was not significant (P = 0.30) (Table 1). This probability is much greater than the P = 0.10 limit we set for this study. This lack of significance indicates that, in general, we should not expect significant crop of seed cane x cultivar interactions. We also checked individual cultivars for significant interactions with crop of seed cane. Using the LSD of 20.9 tons per acre for the cultivar x crop of seed cane interaction, we tested the significance of the differences in yield of the three crops of seed cane for each cultivar. For example, we tested the significance of the yield of CP 70-1133 with plant-crop seed cane vs. its yield with first-ratoon seed cane. We also tested its yield with plant-crop seed cane vs. its yield with second-ratoon seed cane, and its yield with first-ratoon seed cane vs. its yield with second-ratoon seed cane. We tested all 10 cultivars in this manner, yielding a total of 30 comparisons. Four of the 30 comparisons were significant. Since we expect 3 of 30 to be significant by chance alone with $\alpha = 0.10$, having only 4 significant comparisons indicated that crop of seed cane had minimal effects on the cane yields of the individual cultivars.

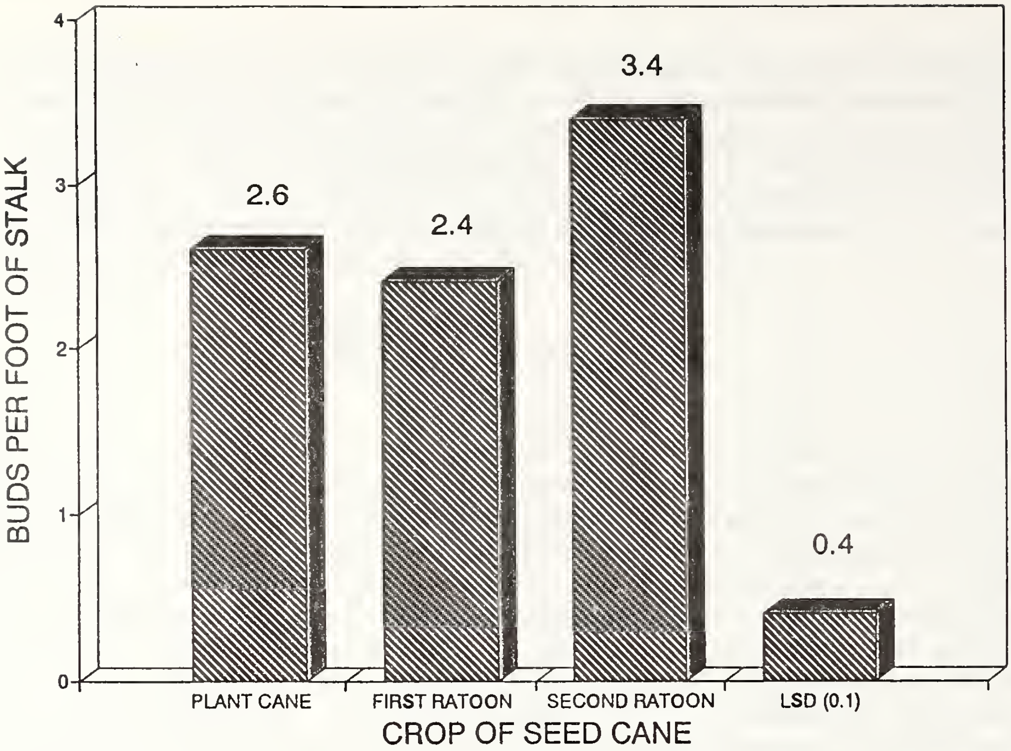

Figure 1. Number of buds per ft of stalk on seed cane from the plant, first-ratoon, and second-ratoon crops.

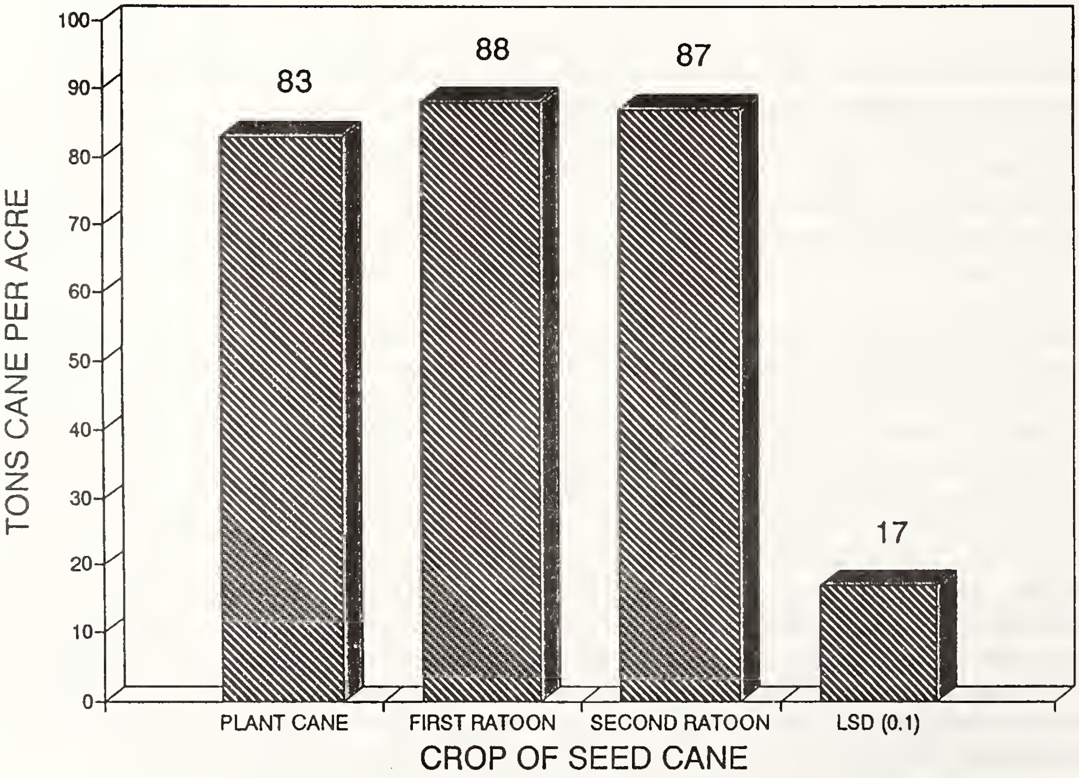

Figure 2. Tons of cane per acre of CP 72-1210 planted with seed cane from the plant, first-ratoon, and second-ratoon crops.

Experiment 2

This experiment included only one cultivar, CP 72-1210. Rather than estimating yields by counting stalks per plot and weighing a small sample of stalks as we did in the first experiment, we weighed entire plots in this experiment. Figure 2 shows that all three crops of seed cane had similar cane yields. These results provided further evidence that growers can use seed cane from ratoon as well as from plant-crop fields without expecting losses in yield. Experiment 1 and some of the results of a previous greenhouse study (4), indicated that using ratoon seed cane rather than plant-crop seed cane would result in yield increases. Experiment 2 indicated that ratoon seed cane would produce yields equal to but not greater than those of plant-crop seed cane.

Experiment 3

This experiment compared the yields of three cultivars and three crops of seed cane (Table 3). Like Experiment 2, the cane yields from plant and ratoon seed cane sources were similar and the overall cultivar x crop of seed cane interaction was not significant (P = 0.49) (data not shown). Only one cultivar had significantly different cane yields between crops of seed cane. The yield from first-ratoon seed cane of CP 74-2005 was significantly greater than its cane yield from second-ratoon seed cane. There were 9 possible comparisons that tested cultivars across the three crops of seed cane as we did in Experiment 1. Having only one significant single degree of freedom comparison, coupled with the overall nonsignificant F value provides strong evidence that the cultivar x crop of seed cane interaction was not important. One would expect 1 of 10 such comparisons to be significant by chance alone with $\alpha = 0.10$.

Table 3. Cane yields of three sugarcane cultivars planted at Canal Point (Experiment 3) with seed cane from the plant, first-ratoon, and second-ratoon crops.

	Crop of seed cane			
Cultivar	Plant cane	First ratoon	Second ratoon	Mean[1]
	Tons cane per acre			
CP 72-1210	117.8	110.5	116.3	114.9
CP 74-2005	153.6	166.3	140.6	153.5
CP 78-1247	123.0	130.4	140.9	131.4
Mean	131.4	135.7	132.6	133.3

[1] LSD (P = 0.10) for determining differences among cultivar means is 14.2 tons cane per acre.

[2] LSD (P = 0.10) for determining differences among crops of seed cane is 14.2 tons cane per acre and for cultivar x crop of seed cane interactions is 24.6 tons cane per acre.

The information is not shown, but this experiment also analyzed sugar concentration, tons of sugar per acre, and stalk weight. The sugar concentrations and sugar tonnages were similar for all three crops of seed cane. The stalk weight results were surprising. Using second-ratoon seed cane resulted in significantly greater stalk weight than plant-crop seed cane. In addition, the stalk weight of cane planted from first-ratoon seed cane was almost significantly greater than that planted from plant-crop seed cane (P = 0.12). The stalk weights of the two ratoon-seed cane treatments did not differ significantly. These results differed with those of Experiment 1 which discovered no differences in stalk weight due to crop of seed cane.

General Conclusions

We conducted a series of field studies during 4 years to determine if sugarcane growers in Florida should continue to use plant-crop fields almost exclusively as their sources of seed cane. In earlier greenhouse studies, we reported that for most cultivars, emergence of seed cane from ratoon fields was at least equal to emergence from plant-cane fields (4). However, some cultivars had better emergence with seed cane from the plant crop as opposed to ratoon seed cane and vice versa. In one of the three field experiments described here, seed cane from second-ratoon fields produced significantly more tons cane per acre than seed cane from plant-crop fields. Otherwise, crop of seed cane had little effect on cane yields. Also, the overall cultivar x crop of seed cane interactions were not significant in this study, and no individual cultivar displayed consistent unusual reactions to changes in crop of seed cane. Based on these results, growers should expect seed cane from the first- or second-ratoon crops to yield at least as much cane per acre as seed cane from the plant crop. In choosing seed cane fields, growers should place more emphasis on logistical concerns and using disease-free seed cane than on crop of seed cane.

ACKNOWLEDGMENT

We gratefully acknowledged the technical assistance of Robert Florence.

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RATOON STUNTING DISEASE AMONG SUGARCANE CULTIVARS IN FLORIDA'S UNTREATED SEEDFIELDS

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ABSTRACT

The incidence of ratoon stunting disease (RSD) in commercial sugarcane seedfields in Florida is suspected to be high. Our objective was to conduct a limited survey to obtain an indication of the RSD incidence. Incidence of RSD in commercial sugarcane seedfields where seedpieces were not treated with hot water to control RSD ranged from 0 to 100% with most fields having a high incidence of infection. Of 15 cultivars examined, the cultivar CP 82-1592 had the lowest mean incidence of RSD with 1.9% stalks infected, whereas cultivars CL 61-620 and CP 72-1210 had the highest incidence of RSD with 100% stalk infection. The incidence of infection for other cultivars was between these two extremes. A tissue blot immunoassay was used to determine the mean number of colonized vascular bundles by the RSD bacterium. The mean number of colonized vascular bundles per 1 cm diameter core of stalk ranged from 0.06 in cultivar CP 82-1592 to 10.8 in CL 61-620. A correlation coefficient ($r = 0.76$) between mean number of colonized vascular bundles and field incidence of the disease was found. These limited data suggest cultivar differences in RSD susceptibility.

INTRODUCTION

Ratoon stunting disease (RSD), caused by *Clavibacter xyli* subsp. *xyli* Davis et al. (2), is reported to cause yield losses in sugarcane (3,4,7,9). Losses can be considerable if drought conditions stress the plant. For years, RSD was not considered a problem in Florida except by plant pathologists. Due to adequate rainfall during the growing season, plants generally were not stressed by the drought conditions that accentuate yield losses to RSD. An average 5% annual yield loss of sugar per hectare has been projected (3) based upon documented yield losses in commercial cultivars and their acreage.

Until recently, surveying fields for RSD was difficult because reliable visual symptoms for diagnosing infected plants do not occur (4). The tissue blot immunosorbent assay (TBIA) developed by Harrison and Davis (6) and the dot blot technique used by Irvine and Irey (8) are reliable techniques that can be used to survey seedfields to determine the incidence of RSD infection. In Florida, it has been assumed that newly-released cultivars are relatively free of disease and that, over time, the incidence of RSD in commercial plantings increases as a function of a cultivar's susceptibility. The build-up of RSD is to be expected since hot-water-treated seedcane has not been used until recently. Two sugarcane companies have initiated hot-water seed treatment programs for control of RSD, however, only one program has been in place for sufficient time that a significant percentage of the crop is planted with recently hot-water-treated seedcane.

The objectives of this research were to survey plant- and ratoon-crop seedfields of commercial cultivars that had not been hot-water treated and to determine: (1) RSD incidence; (2) the average number of colonized vascular bundles (CVB) for each cultivar; and (3) the correlation between CVB and disease incidence.

MATERIALS AND METHODS

Plant- and (first or second) ratoon-crop seedfields of mature cane of 15 commercial cultivars were sampled during the period of September 15 through November 21, 1991 at Okeelanta Corporation, South Bay, FL. The cultivars sampled with the number of seedfields sampled in parentheses were: CL 61-620 (3), CL 73-239 (2), CP 70-1133 (2), CP 72-1210 (2), CP 73-1547 (2), CP 78-1628 (1), CP 80-1743 (2), CP 80-1827 (5), CP 72-2086 (4), CP 78-2114 (5), CP 81-1254 (2), CP 81-1302 (2), CP 82-1172 (2), CP 82-1592 (2), and CP 85-1382 (1). Twenty-nine single stalk samples per field, 25 to 40 cm long, were cut one per stool, at ground level. Samples were taken 30 meters from the end of each seedfield perpendicular to the rows sampling only one stool per row.

Stalk samples were assayed using TBIA conducted according to the method established by Harrison and Davis (6). The developed membranes showed the impression of the vascular bundles with RSD-colonized vascular bundles (CVB) stained blue. The CVB were counted using a digital image analysis system. The average number of CVB and incidence of stalk infection per field for each cultivar was calculated.

The relationship between CVB and incidence was examined using correlation which was calculated using SAS (10).

RESULTS AND DISCUSSION

Incidence of RSD-infected stalks in individual seedfields ranged from 0 to 100%; however, disease incidence was high for most cultivars. Approximately 50% of the fields had an RSD incidence of 70% or higher. Commercial cultivars, CL 61-620 and CP 72-1210 had overall infection incidences of 100% and CP 70-1133 had an incidence of 86.7% (Figure 1) based on the limited fields sampled. Together, these three cultivars currently account for 47.1% of Florida's sugarcane acreage (5). The mean infection levels for all cultivars, except CP 80-1743, CP 72-2086, and CP 82-1592, were over 50% stalks infected. Since decreased yields due to RSD infection have been demonstrated in yield tests (3,7), it is reasonable to speculate that commercial yields in infected fields probably are decreased due to RSD. The newest cultivar, CP 82-1592, had the lowest overall incidence of 1.9% stalks infected with no RSD being detected in one of the two fields sampled. The low RSD incidence in CP 82-1592 could be either because the cultivar is a recent release that has not received the RSD exposure that older, more established cultivars have received, or that the cultivar is resistant. Preliminary screening results suggest that CP 82-1592 is resistant to RSD, but these results require confirmation.

The relationship between average number of CVB, susceptibility, and incidence has not been fully investigated. However, the number of CVB may be indicative of the relative population of *C. xyli* subsp. *xyli* that develops within a cultivar. This could then indicate cultivar susceptibility to infection by the RSD pathogen. It is based on this assumption that cultivars are evaluated for their RSD reaction. The CVB number is used to categorize a cultivar's susceptibility to infection: a low number of CVB indicates RSD resistance; a high number indicates susceptibility. Although the number of fields sampled was limited, the variability in RSD incidence (Figure 1) and number of CVB (Figure 2) between cultivars in the survey suggest that the current cultivars differ in RSD susceptibility. Cultivar CP 72-2086 appears resistant since it had a mean number of 0.8 CVB per 1 cm diameter core of stalk, whereas CL 61-620, CP 72-1210 and CP 70-1133 are probably more susceptible since they had overall means of 10.8, 7.1 and 6.8 CVB per core, respectively (Figure 2).

To speculate, differences in susceptibility probably contribute to differences in rate of spread of RSD and the disease incidence that occurs if no controls are implemented. Fields of cultivars with high means for number of CVB would be expected to have a high incidence of RSD. A significant correlation (r= 0.76) was detected between the means for number of CVB infected per field and incidence of RSD supported this speculation.

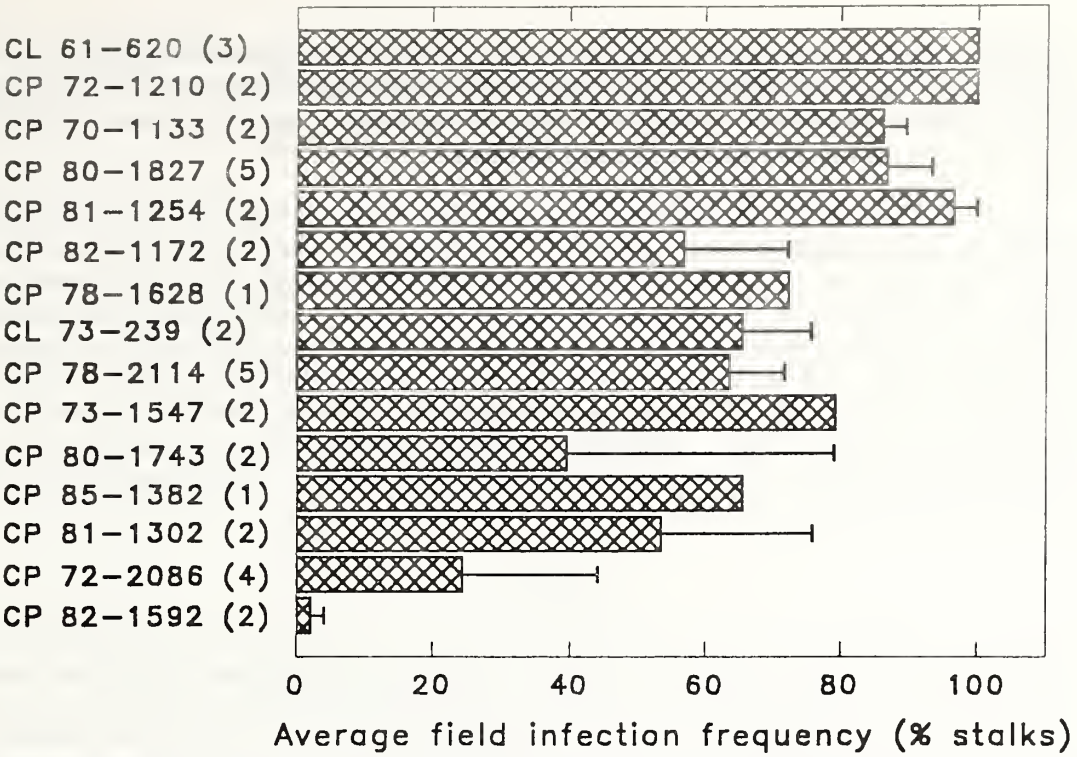

Figure 1. RSD field infection frequency (% stalks) means and standard errors of sugarcane cultivars sampled from commercial seedfields lacking any hot-water-treatment. Number of fields sampled is indicated in parentheses after the cultivar name.

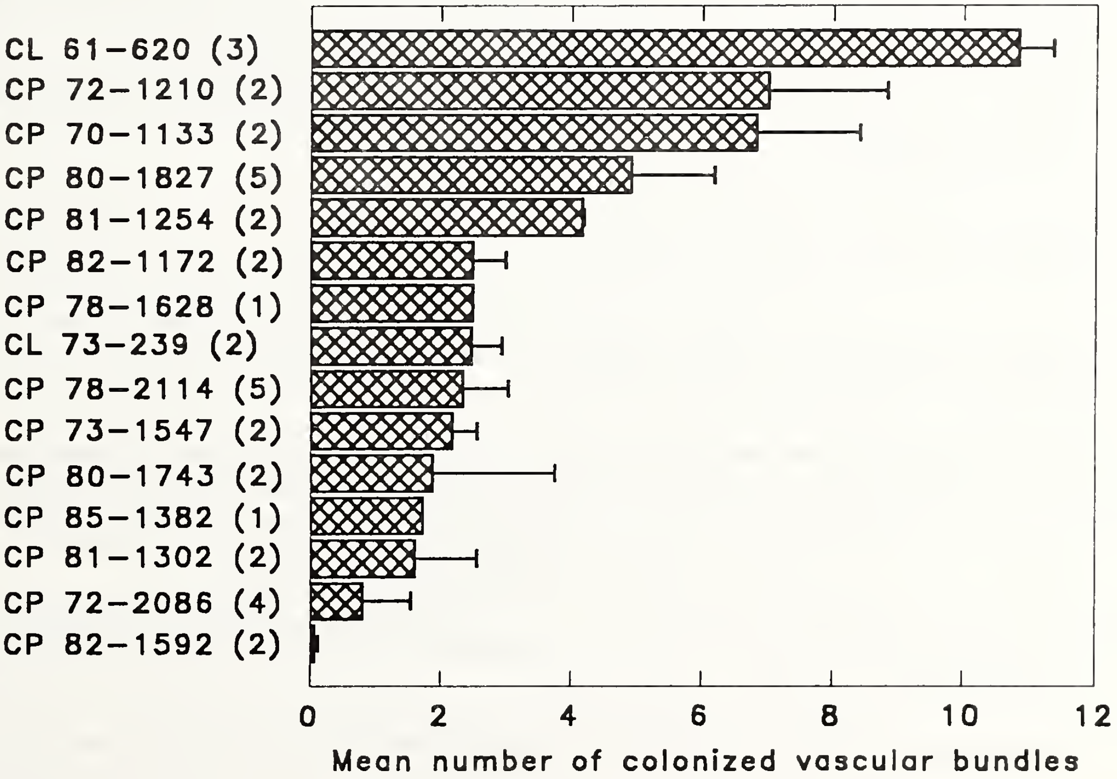

Figure 2. Means and standard errors for number of RSD colonized vascular bundles found in sugarcane stalks sampled from commercial seedfields lacking any hot-water-treatment. Number of fields sampled is indicated in parentheses after the cultivar name.

The levels of RSD in the recently-released cultivars CP 82-1172, and CP 81-1302 were 57 and 53%, respectively. Values of this magnitude suggest that RSD may spread rapidly in a susceptible cultivar after release if no attempt is made to control it. Research is needed on factors affecting the rates of spread and increase of RSD in different cultivars.

The survey results emphasize that RSD is a problem requiring control in the Florida industry. Two control strategies should be used together. First, all seedcane should be hot-water-treated to establish RSD-free seed nurseries, and proper field sanitation practices should be utilized for their maintenance. The efficiency of heat therapy in disinfecting seedcane has already been documented (4). A monitoring system to determine the incidence of RSD in seedcane also should be implemented to monitor disease within the hot-water treatment program. Second, RSD resistant cultivars should be grown when available. Sugarcane variety development programs in Florida are currently breeding for RSD resistance. Since 1989, clones selected from Stage II in our breeding program have been screened for RSD resistance (1). Ultimately, RSD resistant cultivars will be developed that will replace the current susceptible cultivars.

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MORTALITY OF SUGARCANE BORER (LEPIDOPTERA: PYRALIDAE) TREATED WITH ENTOMOPATHOGENIC NEMATODES IN FIELD AND LABORATORY TRIALS

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ABSTRACT

Experiments were conducted to evaluate entomopathogenic nematodes as possible biological control organisms against sugarcane borer larvae. Three species of entomopathogenic nematodes were evaluated for their effectiveness against the sugarcane borer, *Diatraea saccharalis* (F.), in a laboratory trial. *Steinernema carpocapsae* (Weiser) and *Heterorhabditis bacteriophora* Poinar nematodes caused 100% mortality of 3rd-4th instar sugarcane borer larvae dwelling inside a laboratory insect diet when 5,000 nematodes were applied in 1 ml of water to the surface of the diet; *S. glaseri* caused only 30% mortality. The same concentration of *S. carpocapsae* caused 95% mortality of sugarcane borer larvae tunnelling inside pieces of sugarcane stalks. The study indicated that at least some entomopathogenic nematodes have the ability to find and kill borers dwelling inside sugarcane stalks under laboratory conditions. However, *S. carpocapsae* applied at 3.7 billion nematodes/ha in a water spray at dusk failed to control borers inside stalks in an informal field test.

INTRODUCTION

The sugarcane borer, *Diatraea saccharalis* (F.), is a major pest of sugarcane (a complex hybrid of *Saccharum* spp.) in the western hemisphere (2). Biological control, chemical control, and plant resistance (alone or in combination) have been used to control this pest.

Entomopathogenic nematodes have been investigated for control of the African sugarcane stalk borer, *Eldana saccharina* Walker and a moderate level of control was achieved (5). The *Eldana* borer infests sugarcane stalks in much the same manner as the sugarcane borer. Entomopathogenic nematodes were also tested against the currant moth borer, *Synanthedon tipuliformis* (Clerck), in blackcurrants in Australia. Larvae of this pest feed extensively on pith within the stem of host plants. Tests by Miller & Bedding (1) demonstrated that high levels of infection of currant moth borers can be achieved in the field with applications of *Neoaplectana bibionis* Bovien.

The purpose of this study was to evaluate entomopathogenic nematodes as possible biological control organisms for control of the sugarcane borer.

MATERIALS AND METHODS

A laboratory test was conducted in which individual third-instar sugarcane borers in an artificial medium in 30 ml diet cups (ca. 10 ml of diet/cup) were treated with entomopathogenic nematodes. Nematodes were placed on top of the medium in concentrations of 50, 100, 500, 1,000, and 5,000 nematodes in 1 ml of water per cup. The controls received only water. Twenty borers were exposed to each concentration of each of three nematode species: *Steinernema carpocapsae* (Weiser), *S. glaseri* (Steiner), and *Heterorhabditis bacteriophora* Poinar obtained from the laboratory of W. J. Schroeder. Larval mortality was determined after 7 days.

In a second laboratory trial, mature stalks of the sugarcane cultivar CP 65-357 were sectioned into pieces 50 cm long. A single piece was placed inside each of 50 PVC tubes (10 cm dia. X 60 cm long). Five sugarcane borer 3rd-4th instar larvae were introduced into each tube. The ends of the tubes were then capped with wire screen to prevent larvae from escaping. After 5 days, the cane piece was removed from each tube, thoroughly wetted to the point of dripping with a suspension of 5,000 *S. carpocapsae*/ml of water using a spray bottle, and returned to the tube. This concentration was selected because it provided 100% mortality of sugarcane borer larvae in the first laboratory assay. Forty cane pieces received the nematode treatment and the remaining 10 were treated with plain water as a control. Larval mortality in each tube was determined after 7 days.

An informal field trial was conducted in Hendry County, Florida, in sugarcane growing on sand (>95% silica). A first-ratoon crop of sugarcane cultivar CL 41-191 was found on November 10, 1989 to be naturally infested by sugarcane borer larvae. On November 13, four plots, 2 rows by 6.1 m long, were sprayed with a suspension of *S. carpocapsae* nematode at a rate of about 3.7 billion nematodes per ha using a pump-up hand sprayer calibrated at 47 liters/ha. The treatment was applied during the evening to minimize adverse effects of ultra-violet rays and heat on nematodes. Nine days after the nematodes were applied, at least 10 larvae (dead or alive) were collected from each of the four sprayed plots as well as from an untreated plot. Live larvae were placed in 30 ml cups with a small piece of cane for food and observed for ten days to determine if they were infected with nematodes. Dead larvae were screened for nematodes by placing each larva in a petri dish designed to collect emerging infective-stage nematodes (3).

RESULTS AND DISCUSSION

Of the three nematode species studied, *H. bacteriophora* and *S. carpocapsae*, at 5,000 nematodes/diet cup, each caused 100% mortality of sugarcane borer larvae under laboratory conditions (Table 1). The mortality caused to borer larvae by these two species of nematodes was greater at all concentrations than that caused by *S. glaseri*. Because *S. carpocapsae* was effective against the sugarcane borer in this test and since it was available as a commercial product, this nematode was chosen for the other studies presented here.

Table 1. Mortality of third instar sugarcane borer larvae in individual cups containing a laboratory diet treated with various concentrations of three species of entomopathogenic nematodes.

Nematode rate per diet cup[1]	*S. carpocapsae* Number dead	(%)	*S. glaseri* Number dead	(%)	*H. bacteriophora* Number dead	(%)
0	0	(0)	0	(0)	0	(0)
50	13	(65)	1	(5)	15	(75)
100	16	(80)	1	(5)	15	(75)
500	17	(85)	7	(35)	18	(90)
1000	19	(95)	9	(45)	19	(95)
5000	20	(100)	6	(30)	20	(100)

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[1] Each rate was applied in 1 ml of water per 30 ml diet cup, about 10 ml of diet per cup.

Of the 200 sugarcane borer larvae dwelling inside pieces of sugarcane stalks treated with *S. carpocapsae*, 126 larvae and 4 pupae were recovered at the end of the test. A total of 120 (95%) of the recovered larvae were dead due to nematodes, and 6 were alive. Three pupae recovered were alive, and one was dead due to nematodes. *S. carpocapsae* was therefore 93% effective against sugarcane borer larvae and pupae in this test. While some borer larvae may have been directly exposed to nematodes at the time of application, some larvae were inside cane pieces. These results show that nematodes are capable of moving through the frass and into borer tunnels. With respect to the 70 larvae not recovered at the end of the test, there are several possible explanations. Some may have escaped or remained undetected when the cane was dissected, some may have died and decomposed, and others may have been victims of cannibalism. Thirty-seven larvae (74%) were recovered from the 10 control sugarcane pieces and all were alive.

In the informal field test, a total of 50 borer larvae tunnelling inside stalks were recovered from sugarcane sprayed with *S. carpocapsae*. Of these 50 larvae, 17 were dead. In cane not sprayed with *S. carpocapsae*, 9 borer larvae were recovered and one was dead. In the laboratory, nematodes emerged from only one of the 17 dead borers recovered from the treated cane; these nematodes appeared to be *S. carpocapsae*. Other dead borers from the sprayed plots may have been collected after nematodes had emerged, or they may have been killed by some cause other than *S. carpocapsae*. No nematodes emerged from the one dead borer collected from the untreated sugarcane. None of the 33 live larvae collected from plots sprayed with *S. carpocapsae* died during a 10 day observation period in the laboratory, nor did any of the 8 live larvae from the cane not sprayed.

In summary, we found that the entomopathogenic nematodes *S. carpocapsae* and *H. bacteriophora* were generally more effective against sugarcane borer larvae growing on artificial media than *S. glaseri*. *S. carpocapsae* nematodes appeared to have the ability to seek, infect, and kill borer larvae tunnelling inside sugarcane stalks under laboratory conditions. However, in the informal field test, nematodes were recovered from only one dead borer. A good assessment of controlling sugarcane borers with entomopathogenic nematodes under field conditions remains to be conducted. Better control of sugarcane borers might have been achieved if we had applied a higher rate of nematodes. There may be other nematode species that are more effective than *S. carpocapsae* against *D. saccharalis* in sugarcane in south Florida. Our laboratory tests indicate that *H. bacteriophora* is a good candidate. Other researchers have had success against lepidopterous borers with nematodes applied in water sprays (5, 1). However, nematode survival and consequently biological control of the sugarcane borer in Florida might be enhanced if nematodes were applied in a starch polymer, such as Ag Sorbent Flakes (Super Absorbent Co., Lumberton, N.C.)[1], that retains water (4). The use of an application medium such as this may increase borer mortality by protecting the nematodes until environmental conditions allow them to begin searching sugarcane borer larvae.

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EFFECT OF FLOODING ON SELECTED SUGARCANE CLONES AND SOIL INSECT PESTS

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ABSTRACT

Sugarcane fields in Florida commonly become flooded following a heavy rain, which may affect both the crop and soil insect pests. Previous studies have indicated that sugarcane cultivars vary for their ability to produce cane under flooded conditions and that flooding is a means of controlling soil insect pests. This study was conducted to measure the effect of flooding on cane production of a selected group of clones and mortality of cane pests *Ligyrus subtropicus* (grubs) and *Melanotus communis* (wireworms). Eight sugarcane clones were evaluated for two crop years when grown under flooded and conventionally-drained control conditions. Plots also were assayed for grubs and wireworms, and mortality due to flooding was evaluated. Ratoon cane production was reduced in the flooded environment, and clones demonstrated a range of ratoon productivity under flood. Flooding killed 100% of *L. subtropicus* grubs after one week. *M. communis* was much more tolerant of flooding, with 72% mortality after 6 weeks of flooding. The regression coefficient of *M. communis* mortality and duration of flood was $r^2 = 0.50$, $P < 0.01$.

INTRODUCTION

Sugarcane fields in south Florida commonly flood following a heavy rain. Usually water is removed as quickly as possible. However, at times retention of water on fields may be of benefit, particularly for controlling soil-borne insect pests. The purpose of these experiments was to evaluate the effect of flooding on cane production and soil insect pests.

Previous investigations have evaluated sugarcane clones in Florida under high water table conditions (9) and under flood (6). In the latter study, clones were identified which appeared to vary for cane production, particularly in ratoon, when grown in small (2m), flooded plots. The present experiment was conducted on a selected group of those clones utilizing larger plots to re-examine earlier results. In addition, previous studies showed that flooding was an effective control for many soil-inhabiting insect pests (4, 5, 7, 8). This experiment was a field verification of those observations, using long-term flooding of sugarcane fields, which was not tested in previous studies.

MATERIALS AND METHODS

Cane Production

The eight sugarcane clones evaluated in this experiment (Table 1) were chosen based on their respective cane production under flood in a previous experiment (6). Clones were planted in two test environments, flooded and conventionally-drained control. Within each environment, clones were planted in two-row, 5m plots in a randomized complete-block design with 4 replications. Border rows were planted around the field. Plots were fertilized according to soil test recommendations (10). The flooded test was planted on 25 January 1990, initially flooded on 2 July,[1] and finally drained on 18 December. During the flood period, the water level was maintained at about 30 cm, except when the test was drained from 8 August until 18 September due to a broken pump. The control test was planted on 7 February 1990. The experiment was harvested on 8 and 9 January 1991. Whole plots were cut and weighed. The ratoon crop was flooded on 17 June 1991, drained on 22 November, and the complete experiment was harvested on 12 December.

Table 1. Mean cane yields of eight sugarcane clones grown under flood for two crop years.

	Plant Cane			Ratoon		
Clone	Control	Flood	F/C*	Control	Flood	F/C*
	-----Mg ha^{-1}-----					
CP86-1664	164	197	1.20	216	88	0.41
CP86-1665	140	132	0.94	166	69	0.42
CP86-2047	128	115	0.90	162	68	0.42
CP86-1331	123	114	0.92	143	120	0.84
CP86-1967	101	126	1.25	101	65	0.64
CO 281	95	91	0.95	128	61	0.48
CP86-1508	91	84	1.04	87	20	0.24
POJ 2725	42	60	1.42	85	21	0.22
LSD .05	21	26		37	41	
.01	28	35		50	56	

*F/C is a ratio of production in flood to production in control.

Plot weights were used to estimate cane production (Mg ha^{-1}) in the flood test and in the control. An analysis of variance was calculated and clone means separated with Fisher's LSD (3) for each environment. In addition, a ratio of production in flood to production in control was calculated for each clone as an estimate of its flood tolerance.

Soil Insect Populations

Populations of grubs (Family Scarabaeidae) and wireworms (Family Elateridae) were monitored in the flooded and unflooded plots described above from April 1990 to Dec. 1991. Sampling was conducted at four different times (Table 2) to compare population changes through time in the two areas. At each of the four sample times, flooded and unflooded areas were sampled at the same time by collecting 20 samples from each of the two areas. Each sample was obtained by randomly selecting a sugarcane plant and then digging up a 25 x 25 x 20 cm deep soil sample from under the plant. Plant roots were also examined when the stool was dug up and any insects found were included in the soil sample. Each soil sample was put in a bucket and later visually examined in a laboratory to recover grubs and wireworms. Insects were then stored in alcohol and identified microscopically. Means ± SE are presented for insects/plant for each plot at each of the four sample times.

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Short-term Flooding of Insects

Additional experiments were conducted to determine the effect of flooding standing sugarcane for different time intervals on mortality of grubs and wireworms. Larvae of both species were collected by digging under sugarcane plants in commercial sugarcane fields from July to Nov., 1990 and 1991.

Table 2. Grubs and wireworms found in flooded versus unflooded sugarcane.

	Mean ± SE insect/plant[a]	
	Flooded	Unflooded
1st Pre-Flood (April, 1990)	0 ± 0	0.1 ± 0.1
1st Post-Flood (Jan., 1991)	0 ± 0	1.1 ± 0.4
2nd Pre-Flood (June, 1991)	0 ± 0	0.3 ± 0.1
2nd Post-Flood (Dec., 1991)	0 ± 0	1.5 ± 0.4

[a] Total insects collected = 28.3% grubs + 71.7% wireworms. Grubs = 61.5% *Anomala marginata* + 38.5% *Cyclocephala parallela*. Wireworms = 3.0% *Conoderus* spp. + 42.4% *Glyphonyx bimarginatus* + 54.5% *Melanotus communis*.

After collection, larvae were stored in plastic pans filled with muck and sliced carrot for food and held in a laboratory at ca. 25°C. In flooding tests, 10 grubs (third instar larvae) of *L. subtropicus* or 10 wireworms (larvae) were put into a 30 x 22 x 11 cm plastic pan about two-thirds filled with muck and sliced carrots. Pans used as controls in the unflooded plots had hard plastic tops, and pans used in the flooded plots had a screen top to allow water in while preventing the escape of insects. To simulate field flooding, a pan with insects was placed underwater at ground level under fallen sugarcane leaves in the flooded plot. This pan was paired with a control pan containing insects of the same species which was placed underneath a sugarcane plant on the same day in the unflooded plots.

Flooding mortality in insects may be dependent on water temperature (4, 8). Hence, pans were placed in the plots at different dates from Aug. to Dec. 1990 and 1991 to get average flood mortalities expected during that period. *L. subtropicus* grubs were tested for 1-week periods at five different dates between Aug. and Dec. At each date a pan was placed in the flooded field and the control field for one week The one week flood duration was chosen based on high mortality of *L. subtropicus* grubs previously reported at this flood interval (12, 4). *M. communis* was tested similarly except pans were kept in the field for 1, 4, and 6 weeks. This is, at five different dates between Aug. and Dec., paired (flood and control) pans were placed in the field to remain for 1, 4, and 6 weeks. The maximum 6-week flood duration was chosen based on high mortality to *M. communis* larvae previously reported at this flood interval (7). Water and soil temperatures of adjacent pans were recorded mid-point of each experiment. After each test, pans were taken to the laboratory where insects were recovered. Insects were held at ca 25°C in dry soil for 48 h and then survival was determined, since the flooded insects were comatose when first recovered from water. Means ± SE are presented for *L. subtropicus* mortality in flooded versus unflooded plots. Flood mortality to *M. communis* at 1, 4, and 6 weeks was adjusted for control mortality using Abbott's formula (1925). Linear regression analysis was used to determine the relationship between *M. communis* flood mortality and flood duration.

RESULTS AND DISCUSSION

Cane Production

In the analysis of variance combined across crops (Table 3) all sources of variation were significant ($P < 0.05$) except replications within environments. Further analyses of variance were calculated for each crop year-environment combination. Clone means from these combinations are presented in Table 1. In plant cane there were significant differences between clones, but all clones produced as well in flood as they did in the control. This may be due in part to the fact that the previous crop in the flood environment was rice, which has been shown to have a favorable effect upon subsequent cane crops (2, 11). In addition, the field was inadvertently drained through August and half of September, when cane grows very rapidly. The favorable conditions for growth may have reduced or modified the effect of flooding on some clones.

Table 3. Analysis of variance for cane production of eight sugarcane clones grown in two environments (flood and drained control) for two crop years.

Source	df	Mean Square	P > F
		$(Mg\ ha^{-1})^2$	
Environment	1	35079	<0.001
Reps (Env.)	6	612	0.285
Crop	1	4692	0.003
Env. x Crop	1	48011	<0.001
Rep. x Crop (Env.)	6	240	
Clones	7	20824	<0.001
Env. x Clones	7	1240	0.020
Crop x Clones	7	1129	0.032
Env. x Crop x Clones	7	1685	0.003
Error	84	486	
TOTAL	127		

In the ratoon crop all clones in the flooded plots dropped in cane production. The ratio of production in flood to production in control ranged from 0.84 for CP 86-1331 to 0.22 for cultivar POJ 2725. Most clones were in the 0.4 to 0.5 range. In the earlier, small-plot experiment (6), CP 86-1331 had the greatest flood to control production ratio and CP 86-1508 and POJ 2725 were the least productive in ratoon. Ratoon flood to control production ratios of the present experiment had a significant linear correlation ($r = 0.89$, $P < 0.01$) with those of the previous experiment (6).

Soil Insect Population

Grubs and wireworms found in the flooded versus unflooded plots are shown in Table 2. No insects of these groups were detected in the flooded plots April 1990 probably because these plots had been in rice production the previous year. The flooding used for rice production had probably killed grubs (4) or wireworms (7) previously present in the plots, and new populations of these pests had not yet built up again. In contrast, a small number of these insects were present in April, 1990 in the unflooded plots since these plots had not been previously flooded. During the remaining three sample periods from Jan. 1991 to Dec. 1991, no grubs or wireworms were found in the flooded plots. Reasons for the absence of grubs or wireworms in flooded plots are as follows. First, the long flood period of six months killed any remaining or undetected grubs or wireworms in the Second, flooding prevents oviposition of adults of grubs (5) and wireworms (7) during the period of inundation. Third, populations of grubs and wireworms did not have time to build up between flood intervals. In contrast, grubs and wireworms were found in unflooded plots on all sample dates. Hence, during the experiment from April 1990 to Dec. 1991, flooded plots had essentially no soil insect pests to damage sugarcane versus unflooded plots in which grubs and wireworms were continually present to feed upon sugarcane plants.

Short-term Flooding of Insects

Mortality of *L. subtropicus* grubs was 100% after one week of flooding. These data are consistent with previous flood tests conducted against this pest (12, 4). An average of 14.0, 47.2, and 71.6% of *M. communis* wireworms died at 1, 4, and 6 week floods respectively. Linear regression showed a significant relationship ($r^2 = 0.50$, 13 d.f., $P < 0.01$) between percent mortality of *M. communis* and flood duration (weeks). This relationship was defined by the equation $Y = 2.2 + 11.5 X$ where Y = percent mortality and X = weeks. The preceding data show several things. First, these data support our observation that grubs and wireworms were essentially exterminated in the flooded plots by the long six month flood in that study. Also, it is noted that *L. subtropicus* grubs are much more easily killed by flooding than *M. communis* larvae. For example, a one week flood in standing sugarcane would be expected to greatly reduce *L. subtropicus* populations, but would have little impact on *M. communis* populations. Genung (1970) reported that a six week flood killed 100% of *M. communis* while our data showed a 71.6% mortality of *M. communis* for the same flood period. However, Genung's tests were conducted during July and August which is warmer than the August to December period used in our tests. In flood tests, Hall (1990) has shown that increased water temperature kills more *M. communis* which corroborates the greater flood kill observed by Genung than we observed. Water temperatures in flooded plots ranged from 18° to 28°C and soil temperatures in unflooded plots ranged from 18° to 27°C.

CONCLUSIONS

The results of these experiments verified results observed in previous tests. For sugarcane production, there appears to be a range among sugarcane clones when subjected to prolonged flood. The ratoon crop is particularly important for assessing the effects of flooding on a clone. For insect control, our data show that a Florida sugarcane grower does not have to flood standing sugarcane for a six month flood, as we used, to benefit from reduced soil insect populations. Rather, even a one week flood will reduce *L. subtropicus* populations and longer floods of four to six weeks will reduce *M. communis* populations.

ACKNOWLEDGEMENT

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THE IMPACT OF SUCCESSION PLANTING AND A THIRD-RATOON CROP ON ECONOMIC EFFICIENCY IN SUGARCANE PRODUCTION IN LOUISIANA

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ABSTRACT

The changing nature of sugarcane production costs coupled with a national sugar policy that fixed prices for raw cane sugar have encouraged many producers to search for alternative rotation production practices. Linear programming (LP) techniques were used to develop a whole farm simulation model for a typical Louisiana sugarcane farm, within a framework of constraints typically found in the Louisiana sugarcane producing region. The objective of this study was to evaluate nontraditional production techniques such as succession planting and a third-ratoon crop in sugarcane production. Results identify labor and non-land capital requirements and economic indicators that measure production efficiency (cost/income ratio, pounds of sugar produced) and standard financial measures such as direct costs, total costs, and net income. A comparison of the cost/income ratios for each rotational option indicates that the nontraditional alternatives increase production efficiency and net farm income. The nontraditional rotation alternatives are nondeterminate in that they are included as alternative enterprise options that may be incorporated into the land use plan within the LP solution.

INTRODUCTION

Changes in sugarcane production costs, coupled with a long term fixed administrative price for raw cane sugar have encouraged many producers to search for alternative rotation production practices. This cost-income squeeze experienced by growers over time has increased the importance of having a better understanding of the costs of alternative production sequences. Sugarcane production is a unique cropping activity in Louisiana in that it is a perennial crop grown in a rotation. The standard practice among sugarcane producers in Louisiana is to harvest a plant- cane, and a first- and second-ratoon crop before leaving land fallow. Thus, approximately one-quarter of the land is fallowed each year in preparation for planting sugarcane the following year. This fallow period involves substantial costs for herbicides and soil preparation. It has been estimated that at least half of the land currently left fallow should remain fallow to control weed, insect, and plant disease problems (C. Richard, 1992 and R. Ricaud, 1992, personal communications). The remaining half of this land could be used for the implementation of an alternative rotation. Previous research has evaluated alternative crops that could be used to replace the fallow element in the rotation (8,9,10). However, the historical monoculture farming system of sugarcane in Louisiana has persisted, indicating these alternatives for fallow were either cost ineffective, deterred timely planting of sugarcane, or required a sizeable acreage to justify the addition of planting and harvest machinery. If producers discover alternative uses for this idled land, within the scheme of their normal rotation, they may increase production efficiency and profits.

The general objective of this paper is to assess the potential effects of changes in rotational production practices on the sugarcane industry in Louisiana. The specific objectives are to first, update the whole-farm sugarcane model developed by Zapata (12) and Shuker (5), based on the methodology provided from previous work by Heagler (2), and assess the impact of the traditional rotation on non-land capital, labor, variable production inputs, production efficiency, and net farm income; second, modify the Zapata/Shuker model to include a third-ratoon option and measure the effects on production efficiency, resource use, and net farm income; third, identify the break even yield of a third-ratoon rotation; fourth, introduce succession planting on sandy soils into the alternative rotation and measure the effect on production efficiency, resource use, and net farm income; and fifth, identify the optimal combination of succession planting and/or a third-ratoon rotation as alternatives in the standard rotation.

A third-ratoon involves allowing another crop to mature after harvest of the second-ratoon. The third-ratoon sequence of operations has one added application of herbicide compared to the second-ratoon sequence. Otherwise, both production sequences are similar. Succession planting involves planting sugarcane soon after harvesting the last ratoon. As succession planting increases, the amount of fallow land decreases. Current succession planting research in Louisiana is constrained to sandy soils. Thus, this analysis does not include the practice as an option on clay soils. Succession planting is a fall activity and competes for resources during the early stages of the regular harvest period. Normally, planting dates extend from the first of October through the first week of November. A fall application of fertilizer in the furrow before planting is required. A spring herbicide application to discourage the spread of bermuda grass is normally applied.

MATERIALS AND METHODS

The farm size selected for this analysis was an 800 acre farm with 60 percent of the land made up of predominately sandy soils and 40 percent of the land comprised of clay soils. Detailed input-output data were obtained from annual cost and returns projections developed with the Mississippi State University Budget Generator (7,3). These data were used to modify the sequence of operations used to produce a traditional rotation documented by Shuker (5). Information provided by Ricaud (4) was used to develop a sequence of operations and establish yield levels for the third-ratoon and succession planting alternatives.

Table 1. Estimated yield levels for plant cane, first, second, and third ratoon and succession planted cane in Louisiana.

	Raw sugar	Cane
	lbs acre^{-1}	tons acre^{-1}
Plant Cane	5850	30.00
First Ratoon	5850	30.00
Second Ratoon	4680	24.00
Third Ratoon		
Sandy Soils	3364	17.25
Clay Soils	3315	17.00
Succession (Sandy Soils)		
Plant Cane	5265	27.00
First Ratoon	5265	27.00
Second Ratoon	3900	20.00

Estimated output levels for all sugarcane alternatives are shown in Table 1. The whole farm linear programming model developed by Zapata (12), and Shuker (6) was updated and modified. All input-output coefficients were reviewed and changed to reflect present technology quantified in current cost of production studies (3). In addition, succession planting and third-ratoon production alternatives were added to the data set. The model's function is to generate physical, economic, and financial data for the analysis. It is based on generally accepted microeconomic and agricultural supply response theories (13). The model is a series of submatrices that are linked to simulate an integrated farm unit. These components are categorized into labor, tractors, individual tools, land use, institutional arrangements such as land rent and mill payments, and overhead and shop functions. The model is made up of 1675 rows and 1870 columns. As the mathematical formulation of the model is very extensive, we omit it from the paper, but it is available from the authors upon request.

Within the model, the simulation process is driven by a set of calendar time frames and the tillage and non-tillage hours associated with each (1). The logical sequence is: activities require tools; tools require power; tools and power require labor and; tools, power, and labor require time. When timeliness of the production process is critical, the length of the calendar time frame may be adjusted. Planting and harvesting were the two most intense and critical periods, and had a series of extremely short time frames. On the other hand, production processes less sensitive to time were assigned longer time frames.

The land use plan for the traditional rotation is characterized by 25 percent of the total land, or 200 acres, allocated to each of the following activities: planting, first- ratoon, second-ratoon, and fallow (Table 2).

Table 2. Land Use plans for sugarcane production scenarios

Production scenarios:	Standard rotation	Std. rotation + third ratoon	Std. rotation + third ratoon + succession
Plant Cane	200 acres	200 acres	200 acres
First-Ratoon	200 acres	200 acres	200 acres
Second-Ratoon	200 acres	200 acres	200 acres
Fallow	200 acres	100 acres	100 acres
Third-Ratoon	XXXXXXXXX	100 acres	40 acres
Succession	XXXXXXXXX	XXXXXXXXX	60 acres
Total land	800 acres	800 acres	800 acres

For a third-ratoon option scenario, the only difference is that half of the fallow land (100 acres) in the traditional rotation remains in fallow in the nontraditional analysis. The remaining 100 acres may be incorporated into a third-ratoon crop. The plan permits up to 60 acres of third-ratoon on sandy soils and 40 acres of third-ratoon on clay soils. The yields at which a third-ratoon crop becomes profitable were identified and used in the evaluation of the third-ratoon alternatives in the simulation model. The land use plan for the nontraditional rotation incorporating both a third-ratoon harvest and succession planting option is slightly different. The previous plan included 100 acres that could be retained in the rotation as a third-ratoon option. In this land use plan, 40 acres of clay soil continue to have a third-ratoon and a fallow option, while the 60 acres of sandy soil is offered fallow, third-ratoon, and the succession options.

RESULTS

The whole-farm linear programming model selected those input and output combinations that maximized net returns for the selected rotation options. Nontraditional scenarios required one additional unit of operating labor and the addition of a tractor, fertilizer applicator, and chopper. All other elements of the traditional machinery complement were not affected by the nontraditional scenarios.

Break even yields at which a third-ratoon crop becomes profitable were identified at 17.00 tons of cane per acre on clay soils and 17.25 tons per acre on sandy soils based on a sugar content of 195 pounds per ton of cane. Yields at or above this level will support a shift from the traditional to a nontraditional rotation containing third-ratoon activities on clay and sandy soils.

Succession planting on sandy soils replaces the third-ratoon option up to the maximum allowed in the model. The combined impact of increased production efficiency and increased productivity had considerable influence on net farm income (Table 3). Additional work needs to be done to identify the break even yield at which a third-ratoon option will compete with succession planting on sandy soils.

Table 3: Production efficiency measures for sugarcane production scenarios

Production scenario	Standard Rotation	Std. rotation + Third ratoon	Std. Rotation + Third-Ratoon + Succession
Sugar production (pounds)			
Total	31,074 cwt	34,500 cwt	35,294 cwt
Grower's share	15,164 cwt	16,836 cwt	17,233 cwt
Costs			
Total costs	$252,582	$266,912	$268,782
Direct costs	$203,660	$211,989	$213,859
Fixed costs	$48,922	$54,923	$54,923
Grower income			
Gross income	$298,732	$331,669	$339,293
Net income	$46,150	$64,757	$70,511
Cost/income ratio	0.846	0.805	0.792

The nontraditional rotations caused both direct and total costs to increase (Table 3). However, productivity and income per rotational acre also increased resulting in a decline in the cost/income ratio. This decline indicates an increase in production efficiency that not only improves net farm income, but also provides more financial flexibility when either yields, prices, and/or production costs are adversely affected. With a standard rotation, 84.6 cents of every dollar of income is absorbed by costs, compared to 80.5 and 79.2 cents with the nontraditional rotations. This implies that the farm realized a reduction in the average cost of production over the course of the entire production process. This effect combined with the increased sugar production results in an increase in net farm income from incorporating the alternative rotations into the cropping system.

There are three ways to increase economic efficiency in sugarcane production. The first way is to increase yields per harvested acre with the same resources. A second way is to maintain yields per harvested acre and reduce production costs. A third way is to modify the land use structure of a rotational acre such that a grower may increase yield and either maintain, increase or reduce cost. The first increases output with no change in input cost, the second maintains output with reduced input cost, and the third increases output and may result in either no change, a decrease or an increase in input cost.

DISCUSSION AND CONCLUSIONS

Recent research developments have led to more favorable considerations of harvesting a third ratoon-crop and succession planting in Louisiana. Better ratooning varieties and the availability of more effective weed control regimes coupled with modifications in agronomic technology have made the production of a third-ratoon crop more favorable (11). Research has also led to the development of agronomic technology that alleviates many of the problems associated with succession planting (4).

Regional production or comparative advantage plays a pivotal role in determining the long run direction of the Louisiana sugar industry. Economic efficiency at the production level is linked directly to production advantage. Louisiana sugarcane producers will not be able to annually fallow 25% of their land and absorb the costs if production costs continue to rise. This analysis indicates that third-ratoon yields of 17 and 17.25 tons per acre on clay and sand soils, respectively, will support a move away from the traditional rotation. Growers can achieve these yields by adjusting their production practices. This analysis suggests that growers may achieve added efficiency by focusing on efficiency per rotational acre; a third-ratoon crop and succession planting have merit in improving production efficiency and increasing the net farm income of sugarcane producers. Improved production efficiency is illustrated by the downward shift in the cost/income ratio when comparing the traditional rotation (.846) with the addition of a third-ratoon option (.805) and a succession/third-ratoon option (.792) on sand and clay soils, respectively. Much of this efficiency gain is realized through more effective use of the existing machinery. This positive impact on net farm income is caused by the combined effect of improved production efficiency with increased productivity.

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RELATIONSHIP BETWEEN CLIMATIC FACTORS AND TIME OF FLORAL EMERGENCE IN SUGARCANE

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ABSTRACT

The two main objectives of this study were to determine the relationships between six environmental factors and time of floral emergence (TFE) in sugarcane (*Saccharum* spp.), and to explore the feasibility of forecasting flowering time of some important varieties used as parents with the goal of seeing what factors could be manipulated by breeders. The data included the natural TFE of six cultivars used as parents (CP 72-1210, CP 65-357, CP 70-1133, CP 72-370, CP 74-383, and CP 72-356) and six climatic factors from 1969 through 1991. The climatic factors were: average minimum temperature in October, average minimum temperature from November 1 to November 15, total rainfall in October, rainy days in October, total rainfall from August through September, and rainy days from August through September. Three models were fitted: the general model included all six climatic factors and two reduced models obtained by stepwise regression. Reduced model B contained variables that were significant at $P \leq 0.15$ while model C contained only variables significant at $P \leq 0.05$. General and reduced models across varieties were significant at $P \leq 0.01$. General and reduced models were also calculated for each variety. This study showed that the average minimum temperature in October had the largest effect on flowering dates, followed by the number of rainy days in October. Thus, one would expect that increasing night temperatures and applying sprinkler irrigation in October would cause earlier flowering.

INTRODUCTION

Photoperiod, temperature, and rainfall are important environmental factors that affect sugarcane flowering. Since photoperiod is fixed at any given latitude and date, many researchers have studied the qualitative relationships between temperature and rainfall and the flowering process. Photoperiodic induction has been shown to occur in Florida from late September to early October. Environmental influences that occur after that would have primary effect on time of tassel emergence (7). The optimum night temperature for floral development was reported to be around 73.4°F (10). The optimum daytime temperature was about 82.4°F (3). Temperatures below 69.8°F were shown by Clements and Awada, 1967 and Nuss and Brett, 1977 to delay panicle growth and emergence. Temperatures exceeding 87.8°F at induction time reduced flowering intensity (3; 5). Temperatures below 64.4°F have been shown to prevent floral induction (4; 6).

Low rainfall has also been shown to reduce the intensity of flowering (1; 12; 15). They also showed that in areas where photoperiod and temperature seldom inhibit flowering, the variation in intensity of flowering between years was primarily the result of differences in annual rainfall. The strong correlation between rainfall and flowering intensity has been used in Hawaii and other locations for prediction of flowering intensity (9; 15).

Although temperature and rainfall have very important effects on time of flowering, their relative importance may change, depending on the location, timing, and varieties being grown. So, it is necessary for every sugarcane breeding station to develop the relationships between these two factors in different developmental stages and their effect upon TFE. The main objectives of this research were to determine the relationships between climatic factors and TFE and to develop prediction equations for forecasting the TFE of several important parental cultivars.

MATERIALS AND METHODS

Six major parental cultivars and six climatic factors were chosen for multiple linear regression analysis (Table 1). The six cultivars (CP 65-357, CP 70-1133, CP 72-356, CP 72-370, CP 72-1210, and CP 74-383) were chosen for use in this study since at least 14 years data were available on the first date the clone was used for crossing. All tassels, used in this study were produced from plants grown in 10 gallon pots in a soil mixture of a ratio of 2 parts muck (euic, hyperthermic Typic Medisaprist) to 1 part washed builder's sand. Plants were started as one bud seed pieces in the greenhouse the last week of January. They were transplanted into the pots on outside growing racks the first week of April. Plants were watered with an irrigation system. Soil moisture should not have been a limiting factor. Plants were fertilized five times at 3 week intervals starting in mid-April with a total pot of 25g N, 10.9g P, 16.5g K plus the micronutrients 0.06g Cu, 0.16g Zn, 0.17g Mn, 0.07g B, and 0.38g Fe. The last application of fertilizer was made the first week of July.

The climatic factors chosen for study were: average daily minimum temperature from November 1 to 15 (X_1), average minimum temperature during October (X_2), total rainfall in October (X_3), total rainfall from August through September (X_4), number of rainy days in October (X_5), and number of rainy days in August and September (X_6). Data were analyzed using SAS, (1988) stepwise multiple regression analysis to determine the effect of these six variables on flowering time. General models for all cultivars and individual models for each cultivar were fitted. All complete models were reduced by stepwise regression until the remaining models were significant at $P \leq 0.01$ level. Two reduced models (B&C) were fitted. The B model included factors that were significant at $P \leq 0.15$. The C model only included factors that were significant at $P \leq 0.05$. The analysis was also done using a stepwise regression in SAS to identify independent variables that were significant at $P = 0.15$, 0.05, and 0.01, respectively.

RESULTS AND DISCUSSION

If one compares the mean low temperature (Table 1) in October 66.8°F and the first half of November 61.7°F with that reported in the literature (10; 4; 6; and 3), very little flowering would be expected and it would be much delayed. Yet, sugarcane consistently produces tassels under natural conditions at Canal Point.

The importance of variables differed among varieties (Table 2). The general model was significant and accounted for 46% of variation in flowering time. When the general model was reduced by stepwise multiple regression, the reduced model still accounted for 45% of the variation in flowering time. The three variables significant in the reduced model were: average minimum temperature in October (X_2), total rainfall in October (X_3), and total rainfall from August through September (X_4). Based on the reduced general model (C), an average 1°F decrease in the minimum temperature in October (X_2) would delay the flowering date by 2.87 days. An increase of 1 rainy day in October would delay the flowering date by 0.77 days. If total rainfall in August and September increased by 1 inch the average date of flowering would be decreased by 1.25 days. Based on these data, it is apparent that there are additional factors that play an important role in floral initiation, inflorescence development, and tassel emergence.

When reduced models are considered for the individual cultivars, (X_2) the average minimum temperature in October was the only variable significant for all cultivars, and as the temperature decreased, flowering was delayed. As number of rainy days in October (X_4) increased, flowering was also delayed in CP 65-357, CP 72-356, and CP 74-383. An increase in the total rainfall in October delayed flowering in CP 72-370 and CP 74-383. An increase in the total rainfall in August and

September (X_6) accelerated the time of flowering in CP 72-356. A decrease in the minimum temperature between November 1 and 5 delayed flowering only in CP 70-1133.

Table 1. Climatic factors and flowering dates of six varieties.

Year	Average Min. Temperature Nov. 1-15	Average Min. Temperature Oct.	Total Rainfall Oct.	Total Rainfall Aug.-Sept.	Rainy Days Oct.	Rainy Days Aug.-Sept.	Flowering Dates(Y_1) CP 65-357	CP 72-1210	CP 72-356	CP 74-383	CP 70-1133	CP 72-370
	X_1	X_2	X_3	X_5	X_4	X_6						
	-------°F-------		------in.-------				--------------------Julian			calendar---------------		
1991	63.3	64.4	2.8	13.5	14	27	325	339	332	325	337	351
1990	57.6	65.1	3.6	8.1	5	23	340	351	354	340	346	
1989	57.6	62.0	3.3	18.0	10	31	347	375	347	347	355	375
1988	63.0	65.6	0.2	14.4	5	30	350	357	364	347		344
1987	66.0	66.9	6.2	8.4	6	16	344	347	356	348	336	347
1986	69.1	68.5	2.3	10.5	8	33	350	339	328	335	328	328
1985	63.1	70.2	3.7	17.4	9	26	330	337	326	330	330	326
1984	61.1	67.3	0.7	12.1	5	26	334	355	341	338	339	331
1983	59.2	69.2	14.2	10.9	14	29	336	336	332	336	332	342
1982	63.8	67.2	5.0	14.7	10	32	337	344	341	326	333	333
1981	60.1	68.0	0.4	18.6	3	30	348	343	341	341	336	341
1980	64.4	68.3	1.4	22.0	6	27	342	344	332	330	342	344
1979	65.0	67.0	3.5	16.1	7	31	332	341	344	341	332	337
1978	64.1	68.7	4.5	18.4	10	32	331	335	331		328	333
1977	61.0	63.8	1.4	20.1	4	33	348	355	343	341	343	339
1976	61.0	64.3	0.3	10.5	3	25	357	354	359		344	
1975	63.2	68.0	4.4	13.5	12	25	335	344	337			
1974	61.1	65.0	2.1	13.0	7	34	357					
1973	61.6	67.4	3.4	10.0	11	29	330					
1972	63.0	67.0	1.7	4.3	5	21	340					
1971	63.0	67.0	8.1	11.9	15	31	328					
1970	54.0	67.4	3.8	15.3	11	34	341					
1969	56.3	68.9	8.4	13.9	14	37	332					
Mean	61.7	66.8	3.7	13.7	8	29	340	347	342	338	337	341
S.D.	±3.3	±1.9	±3.1	±4.2	±4	±5	±9	±10	±11	±7	±7	±12

Table 2. General and varietal multiple regression models of climatic factors (X_i)[1/] on the flowering time (Y_i) in six varieties using from 14 to 23 years data.

Varieties	Model	Multiple Regression Models	R^2[4/]
General[2/]	A[3/]	$Y=546-0.27X_1-2.67X_2^{**}+0.60X_3-1.13X_4^{**}-0.03X_5-0.12X_6$	0.46**
Model	C	$Y=539-2.87X_2^{**}+0.77X_3^{**}-1.25X_4^{**}$	0.45**
CP65-357	A	$Y=429+0.15X_1-1.50X_2+0.79X_3-2.21X_4^{**}-0.32X_5+0.78X_6$	0.62**
CP65-357	B	$Y=420-1.22X_2^{+}-1.65X_4+0.51X_6^{+}$	0.58**
CP65-357	C	$Y=353-1.61X_4^{**}$	0.43**
CP70-1133	A	$Y=539-0.82X_1-2.13X_2^{**}-0.03X_3-0.22X_4+0.39X_5-0.42X_6$	0.86**
CP70-1133	C	$Y=534-0.87X_1^{*}-2.13X_2^{**}$	0.77**
CP72-1210	A	$Y=597-0.70X_1-3.02X_2^{**}-0.12X_3-0.52X_4+0.14X_5-0.88X_6$	0.71**
CP72-1210	C	$Y=592-3.67X_2^{**}$	0.62**
CP72-356	A	$Y=559+0.13X_1-2.93X_2^{**}+0.84X_3-1.96X_4^{**}-0.61X_5-0.34X_6$	0.74**
CP72-356	C	$Y=534-2.48X_2^{**}-1.57X_4^{**}-1.00X_5^{*}$	0.71**
CP72-370	A	$Y=671-0.58X_1-4.28X_2^{**}+0.70X_3+0.55X_4+0.73X_5-0.88X_6$	0.77**
CP72-370	B	$Y=647-4.63X_2^{**}+1.03X_3^{+}$	0.64**
CP72-370	C	$Y=618-4.14X_2^{**}$	0.58**
CP74-383	A	$Y=467+0.22X_1-1.96X_2+1.42X_3-2.05X_4^{**}-0.17X_5+0.03X_6$	0.64**
CP74-383	C	$Y=468-1.81X_2^{*}+1.41X_3^{*}-2.00X_4^{**}$	0.62**

1/: Y Stands for time of flowering;
X_1 for average minimum temperature from November 1 to November 15;
X_2 for average minimum temperature in October;
X_3 for total rainfall in October;
X_4 for rainy days in October;
X_5 for total rainfall from August through September; and
X_6 for rainy days from August through September.

2/: General model was obtained by analyzing all data together.
3/: A stands for the complete model; B and C for the reduced models.
4/: +, * and ** show the significance at the 0.15, 0.05 and 0.01 levels, respectively.
The B model includes all variables that were significant at the $P \leq 0.15$ while
the C model includes only those variables significant at $P \leq 0.05$ or 0.01.

An explanation of the above results might be as follows: Most varieties are in the early stages of panicle development in October (7). The transition stages from a vegetative to floral growing point are very sensitive to temperature and moisture stress. In Canal Point, the mean daytime temperatures ranged from 90.1± 1.5, 86.3± 1.5, to 81.7± 2.5°F in September, October, and the first half of November, respectively, and are suitable for floral induction (within the range reported by Clements and Awada, 1967), but the mean night temperatures are less than the optimal 73.4°F described by Nuss (1980). The cultivars were planted in cans and received water by an automatic watering system, therefore soil moisture was not a limiting factor. However, it is possible that the relative humidity was too low to meet the needs for panicle development. Amin et al. (1971) reported that plants misted during the day produced more than twice as many tassels as ones given the same photoperiod treatment but not misted.

Higher night temperatures (not beyond 71-74°F) in conjunction with more rainy days in October should promote panicle development and earlier flowering. The canes are in later stages of panicle development early in November. Only the flowering of CP 70-1133 was delayed by lower night temperatures between November 1 and 15. Varieties left outside flowered later than varieties moved onto the railcart system where night temperatures are controlled between 72-75°F (data not shown). Average flowering dates for the warm treatments were 2 to 3 days earlier than for the same cultivar left at ambient temperature in the can area. Other results at Canal Point suggest that sprinkling growing plants in October might help promote panicle development and make many varieties flower earlier and at higher intensities. In 1991, two of four noble canes (Akoki 22 and *S. officinarum* 8095) were sprinkled three times daily in October. They produced tassels on all stalks and flowered much earlier than usual. *S. officinarum* 8095 flowered on October 30, and was the first variety in the photoperiod house to flower. In some countries, sprinkling was also found to be effective in promoting flowering of some poor-flowering varieties, including some noble canes (15; 13; 8; 2). Additional data under controlled conditions is needed to study the effects of sprinkling on tassel development and time of emergence.

The coefficients of determination (R^2) of the reduced models were fairly high and significant at $P \leq 0.01$, ranging from 0.43 to 0.77 (Table 2). So, the reduced models should provide reasonably good predictions of flowering dates. For some cultivars, such as CP 70-1133, CP 72-356, CP 72-1210 and CP 74-383, both reduced models were the same. The reduced C model for CP 72-1210 and CP 72-370 included only average minimum temperatures in October (X_2). If the average minimum temperature in October was increased by 1°F the C model predicts that TFE would be advanced by 3.7 and 4.1 days, respectively. The C model for CP 65-357 included only rainy days in October (X_4). For each additional rainy day in October, the TFE would be advanced by 1.6 days. The reduced model for CP 70-1133 included two factors (minimum temperature in October and from November 1 to November 15). For each 1°F increase in minimum temperature over the period October 1 to November 15, the flowering date of CP 70-1133 would be advanced by 3.0 days.

The six factors chosen for regression analysis are believed to be the most important ones affecting flowering at Canal Point. Other climatic factors such as the number of cloudy days or light intensity might also play an important role in the flowering response, and be important in the prediction of flowering dates. Also, as more data are accumulated, prediction models can be adjusted to provide more accurate prediction of the TFE of sugarcane varieties. There is also limited evidence (data not shown) that these data could be used to predict heavy flowering years in commercial fields. Prediction of high flowering intensity could become important if flowering suppressors become important in the Florida sugar industry.

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RECURRENT SELECTION FOR COLD TOLERANCE OF SUGARCANE

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ABSTRACT

Many commercial sugarcane cultivars do not have the desired level of cold tolerance for subtropical regions, but clones of *Saccharum spontaneum* from northern latitudes or high altitudes can show considerable tolerance to low temperatures. Attempts to transfer cold-tolerant genes from these *S. spontaneum* clones to commercial cultivars by using interspecific hybridization have not been successful because of the loss of cold tolerance during nobilization. Experiments were initiated to determine the cold-tolerance performance obtained after a first or second-cycle of recurrent selection. Clones obtained from progenies of backcrosses and polycrosses of commercial sugarcane x *S. spontaneum* hybrids and from biparental crosses among the more cold hardy commercial cultivars were evaluated under natural freeze conditions at Gainesville, Florida. Cold tolerance ratings were based on estimated green leaf area following natural freezes. Results from a two-year test indicated that heritability of cold tolerance was low in both populations. The frequency of clones with better cold tolerance than that of the commercial check, NCo 310, was 8% for the commercial cultivar x commercial cultivar population and 22.2% for the backcross-polycross population. While backcross-polycross populations showed a higher frequency of cold-tolerant clones, these clones were low in sugar and high in fiber. The recurrent selection technique of using a combined gene pool of commercial cultivars and *S. spontaneum* may help prevent the loss of the cold-tolerant genes during the process of nobilization and result in new commercial cultivars with improved cold tolerance.

INTRODUCTION

Noble sugarcane originated in the tropical Pacific islands, probably in New Guinea (2). However, modern commercial cultivars derived from noble canes are grown in subtropical regions where they are sometimes subjected to cold weather and are well adapted to warm climates and freezes (3,10,11). Some clones of *S. spontaneum* collected from Turkestan, Northern Iran, and Pakistan show considerable cold tolerance (3,10). Attempts to transfer the cold-tolerant genes from *S. spontaneum* to commercial cultivars through interspecific hybridization have not been successful due to the loss of this character during the process of nobilization (3,4,5). However, some progress has been made by using interspecific hybridization to produce superior cold-tolerant breeding stocks (8,12).

Cold tolerance of sugarcane has been classified into three categories: resistance of leaves and buds to frost damage, resistance of mature stalks to freezing and subsequent deterioration, and the ability to ratoon after a severe winter (1,9). The resistance of leaves to frost damage was genetically controlled (1). Tai and Miller (15) demonstrated that genotype x location and genotype x year interactions had significant effects on cold tolerance of sugarcane, and that heritability of this trait was very low (H = 26%). The gain from selection for cold tolerance is expected to be small due to the number of locations and years required to accurately evaluate the clonal phenotypes.

Recurrent selection is a population improvement method that intermates superior progeny of one population to produce an improved second population. The process is repeated until the desired level of improvement occurs (7). In sugarcane, Breaux (6) reported that sugar content can be successfully increased by recurrent selection. No information is available regarding the improvement of cold tolerance through recurrent selection.

The objective of this study was to determine the cold tolerance performance after first and second cycles of recurrent selection of sugarcane.

Table 1. Percent seedlings selected for superior cold tolerance in progenies derived from bi-parental crosses and polycrosses.

Cross	Total Seedlings	Selected Seedlings	Percent Selection
CP 44-101 x CP 72-355	147	2	1.36
CP 44-101 x CP 70-321	527	7	1.33
CP 44-101 x CP 65-357	1024	11	1.07
CP 44-101 x CP 77-1055	204	1	0.49
CP 79-1380 x CP 70-321	229	1	0.44
NCo 310 x CP 75-1082	255	2	0.78
NCo 310 x CP 70-321	185	4	2.16
NCo 310 X CP 57-526	310	4	1.29
Commercial x Commercial	2881	32	1.11
US 72-1151 x CP 57-526	120	6	5.00
83P3 US 72-1151*	140	2	1.43
83P3 US 72-1289*	364	2	0.55
83P3 CP 44-101*	958	6	0.63
83P4 CP 44-101*	403	2	0.50
83P4 US 72-1289*	359	5	1.39
83P4 US 72-1151*	110	6	5.45
Backcross-Polycross	2444	29	1.19
All Crosses	5335	61	1.14

* Only female parent was identified in the polycross. The parents of 83P3 included CP 76-338, L79-18, CP 44-101, US 71-1151, and US 72-1289. The parents of 83P4 included CP 44-101, US 72-1151, and US 72-1289.

MATERIALS AND METHODS

Two groups of seed were produced during the 1983/84 flowering season. Group one was derived from biparental crosses among relatively cold hardy commercial sugarcane cultivars, NCo 310, CP 44-101, CP 72-321, CP 65-357, and CP 57-526 (Table 1). Group two was obtained from biparental crosses and polycrosses between two commercial cultivars (CP 44-101 and CP 57-526), and one F1 clone (US 72-1511) and one BC_1 clone (US 72-1289) of commercial cultivar x *S. spontaneum* (15). Seed were planted in the greenhouse at Canal Point, Florida, in spring 1984, and transplanted to the University of Florida Agronomy Farm, Gainesville, Florida, in May 1984. At that location ambient temperatures consistently drop below 32°F during the fall and winter. Selections were made in November of the same year. Selection was based on the green % total leaf area for each clone following the natural freezes (10). A total of 61 clones including 32 clones from commercial x commercial cultivar crosses and 29 clones from backcrosses and polycrosses were obtained. Those selected clones plus four commercial checks (CP 65-357, CP 70-321, CP 44-101, and NCo 310) were planted in a randomized complete block design with seven replications in August 1985. Cold tolerance ratings based on the green leaf area following the natural freezes were made in January (plant cane, 27°F for about 1 hour) and November (first ratoon, 29°F for about 1 hour)

1987. Data were analyzed according to a completely random model (Table 2)(13,14). The statistical model is $Y_{ijk} = \mu + \alpha_i + ß_j + (\alpha ß)_{ij} + R_k + e_{ijk}$, where Y_{ijk} = the cold tolerance observation of the i-th genotype (clone) in a plot in the k-th replication and in the j-th crop-year. μ is common observation, α_i is the effect of the i-th genotype, $ß_j$ is the effect of the j-th crop-year, $(\alpha ß)_{ij}$ is the interaction of the genotype and crop-year, R_k is the effect of the k-th replication, and e_{ijk} is the environmental effect and remainder of genotypic effect on the same plot. The components of variance including genotypic component (σ_g^2) and genotypic x crop-year interaction (σ_{gy}^2) were estimated from the expectation of mean squares. Estimates of broad sense heritability $H = \sigma_g^2/(\sigma_g^2 + \sigma_{gy}^2/r + \sigma_e^2/gy)$ and genetic advance ($G_s = (k)(\sigma_g)(H)$) under selection for cold tolerance for each population were calculated separately from estimated variance components (13,15).

Table 2. The mean squares for a mixed model of cold tolerance test of both groups of selections (commercial x commercial and back-crosses-polycrosses).

Source	df	Expected Mean Squares*
Replications(R)	(r-1)	
Years(Y)	(y-1)	$\sigma_e^2 + g\sigma_{ry}^2 + rg\sigma_y^2$
R x Y	(y-1) (r-1)	$\sigma_e^2 + g\sigma_{ry}^2$
Genotypes(G)	(g-1)	$\sigma_e^2 + r\sigma_{gy}^2 + yg\sigma_g^2$
G x Y	(y-1)(g-1)	$\sigma_e^2 + r\sigma_{gy}^2$
Error	y(r-1)(g-1)	σ_e^2

*Variances: σ_y^2 = year, σ_g^2 = genotype, σ_{ry}^2 = replication x year interaction, σ_{gy}^2 = genotype x year interaction, and σ_e^2 = error.

RESULTS AND DISCUSSION

In the initial populations, the number of clones with superior cold tolerance varied among crosses (Table 1). The percentage of superior clones (selection rates) ranged from less than 1% to greater than 5% and averaged about 1%. The results indicated that relatively few clones with superior cold tolerance were derived from biparental crosses and polycrosses. One parental clone, US 72-1151, tended to produce more progeny with superior cold tolerance than did the other parental clones (Table 1).

In the selected populations, the percentage frequency distribution for cold tolerance rating based on the two-year test indicated commercial cultivar x commercial cultivar population appeared to be very normal, while the backcross-polycross population appeared skewed toward a higher rating of cold tolerance (Fig. 1). The mean cold tolerance ratings were 61.88 for the commercial cultivar x commercial cultivar population and 63.9 for backcross-polycross population. The difference in the mean cold tolerance ratings between the two populations was negligible. The percentage of clones exceeding the commercial check cultivar, NCo 310, in cold tolerance was 8% for commercial x commercial population and 22.2% for BC_1 population. Thus, the frequency of superior clones derived from crosses between cold-hardy commercial cultivars was low. The clones derived from backcrosses and polycrosses had a relatively higher frequency of superior cold-tolerant clones, but these clones were low in sugar (12-14% for cold-tolerant clones vs. 15-19% for commercial cultivars) and high in fiber (16-20% for cold-tolerant clones vs. 11-15% for commercial cultivars)(unpublished data). Year and year x genotype variances were much greater than genotypic variances for both populations (Fig. 1). These results suggested that cold tolerance rating was strongly influenced by the environment. Therefore, cold-tolerant selection should be evaluated for several years and several locations before final selection is made (15).

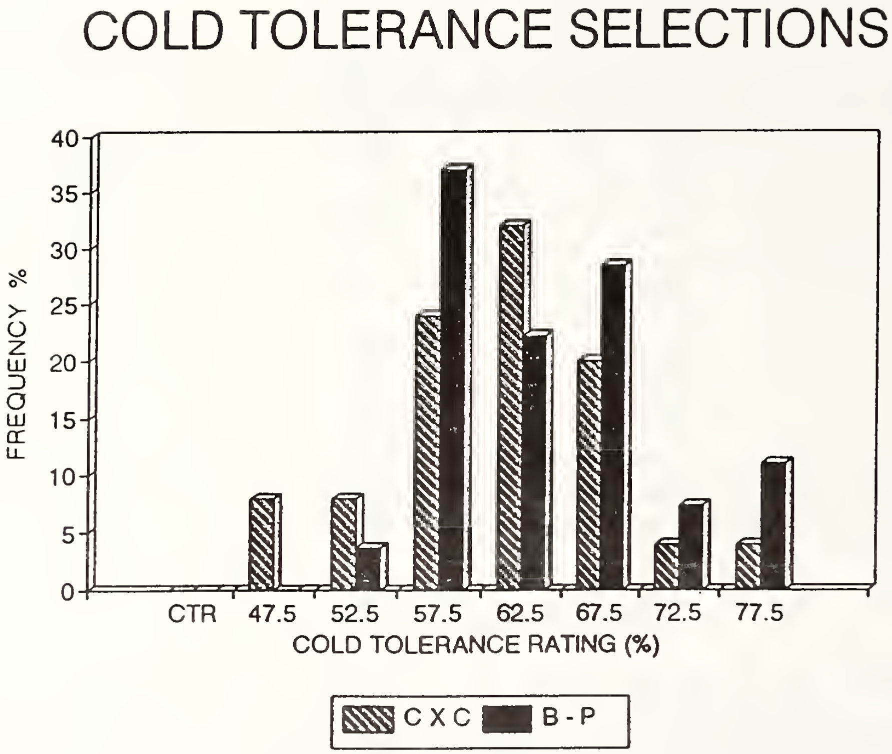

Fig. 1. Frequency distributions (%) for cold tolerance rating of clones selected from commercial x commercial (C x C) and backcross-polycross (B-P) progenies based on two-year tests at Gainesville, Florida. Mean cold tolerance ratings for four commercial cultivar checks from two-year tests were: NCo 310 = 69.64, CP 44-101 = 54.38, CP 65-357 = 53.75, and CP 70-321 = 58.52. Cold tolerance rating was based on the green % total leaf area (complete green leaf = 100% and dead leaf = 0%) following natural freezes.

Broad sense heritability for cold tolerance was 50.3% for the commercial cultivar x commercial cultivar population and 41.3% for the backcross-polycross population (Table 3). Selection for cold tolerance within these two populations appeared to be moderately effective. The expected genetic advances were 5.5% green leaf area for the commercial cultivar x commercial cultivar population and 3.7% green leaf area for the backcross-polycross population. The genetic advances were 9.6% of the population mean of commercial cultivar x commercial cultivar crosses and 5.8% of the population mean for backcross and polycross progenies.

After a two-year evaluation, 15 clones with apparent cold tolerance (3 from commercial cultivar x commercial cultivar crosses and 12 from backcross and polycross progenies) were selected and used as recurrent parents for the next cycle of recurrent selection for cold tolerance. Approximately 10,000 seedlings obtained from these crosses were transplanted to the University of Florida Agronomy Farm, Gainesville, Florida in June 1989. A total of 414 clones with better cold tolerance were selected following exposure to natural freezes in 1989 and 1990. Those clones were planted at the same location in January 1991, for further evaluation.

The experiments indicated that potential exists for increasing cold tolerance in sugarcane by selecting superior clones from commercial cultivar x commercial cultivar crosses and backcross-polycross populations. However, additional cycles of recurrent selection are needed to determine if continued improvement in cold tolerance of sugarcane can be effectively achieved. The recurrent selection technique of using a combined gene pool of both commercial sugarcane cultivar and *S. spontaneum* may help prevent the loss of cold-tolerant genes during the process of nobilization and result in new commercial cultivars with improved cold tolerance.

Table 3. Estimates of variance components, narrow sense heritability (H), and enetic advance (G_s) for cold tolerance of commercial x commercial and backcross-polycross populations.

Variance Component	Commercial x Commercial	Backcross-Polycross
σ_y^2	5754.7038	474.0778
σ_g^2	28.1200	19.2070
σ_{gy}^2	41.7284	39.3144
σ_e^2	96.3801	107.3189
Heritability (H)[1/]	50.31%	41.27%
G_s in average green/generation[2/]	5.49%	3.71%
G_s in % of the mean[2/]	9.61%	5.80%

[1/] $H = \sigma_g^2/(\sigma_g^2 + \sigma_{gy}^2/r + \sigma_e^2/gy)$.

[2/] $G_s = (k)(\sigma_g)(H)$, where the 5% selection intensity for plant materials was $k = 2.06$.

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ELECTROPHORETIC ANALYSIS OF INTERGENERIC HYBRIDS OF SACCHARUM X RELATED GENERA

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ABSTRACT

Variation in the banding patterns of sugarcane isozymes can be used to separate the phenotypes of individual plants. Leaf peroxidase (POD), glutamate oxaloacetic transaminase (GOT), esterase (EST), and glutamate dehydrogenase (GDH) of the progenies of *Saccharum spontaneum* "Uganda" x *Erianthus procerus* "SES 314" and commercial sugarcane cultivars x sweet sorghums were examined by polyacrylamide gel electrophoresis to determine if there are differences in the banding patterns of these isozymes. The results indicated that there were differences between progenies and parents in POD, GOT, and EST banding patterns and these patterns could be distinguished from each other between most of the progeny. Sugarcane x sorghum hybrids presented both common and specific bands of male and female parents and appeared to be true hybrids. The data suggest that the isozyme technique would be a useful tool for sorting the progeny of *Saccharum* x related genera.

INTRODUCTION

Attempts have been made to improve sugarcane through plant breeding since the late nineteenth century. In order to transfer certain useful genes, such as disease and insect resistances, cold tolerance, drought resistance and salt tolerance, into commercial cultivars, crosses between sugarcane and its related genera have been made.

Isozyme techniques have been successfully developed to identify genotypes in many crop plants (5). In sugarcane, however, only limited information is available. Waldron and Glasziou (7) used isozyme patterns to identify sugarcane cultivars and F_1 hybrids and to characterize the genetic differences among *Saccharum* and its related genera. Liao et al. (4) and Wu and Qi (8) presented the results of a peroxidase isozyme study of the progeny of *Saccharum* x *Erianthus arundinaceum*. Wood and Strand (1989, personal communication) used isozyme analysis to estimate the genetic variance of the World Collection of Sugarcane and Related Grasses. Eksomtramage et al. (1), Glaszmann et al. (3) and Glaszmann et al. (2) demonstrated that the characteristics of enzyme banding pattern could be used as genetic markers in sugarcane genetics and breeding.

The objective of the present study was to determine the differences of banding patterns of various isozymes of the progenies *Saccharum spontaneum* x *Erianthus procerus* and commercial sugarcane cultivars x *Sorghum bicolor*.

MATERIALS AND METHODS

Plant materials used in this study included hybrid clones and their parents (Table 1). The crosses were made at the USDA - ARS Sugarcane Field Station, Canal Point, Florida. Selections of the possible hybrid plants of each cross were based on general morphological characteristics. The cuttings of hybrids and parents were sent to the Fujian Agricultural College Sugarcane Research Institute, Fuzhou, Fujian, China, for electrophoretic analyses. Cuttings and sorghum seeds were planted in the greenhouse. The youngest fully open leaf (leaf + 1) from one or two-month-old plants was taken for extracting enzymes. A 2-g portion of each leaf sample was ground in a chilled mortar and pestle and then 4-5 drops of cold extraction buffer (1:4 w/v) were added. The grinding buffer contained 0.5 mM tris, 6 mM 2-mercaptoethanol, 6 mM Na_2EDTA, 5 mM KC1, 5 mM $MgSO_4$ and 2% polyvinylpolypyrrolidone (PVPP) solution adjusted to pH 8.0 with HCl.

Table 1. List of *Saccharum*, *Saccharum* related genera, and their hybrids studied by isozyme analysis.

Entry Number	Parent or Hybrid
1	*Saccharum spontaneum* "Uganda"
2	US 84-1029 [=F_1 (Uganda x SES 314)]
3	US 84-1030 " " " " " "
4	US 84-1032 " " " " " "
5	*Erianthus procerus* "SES 314"
6	CP 63-588 (commercial cultivar, a complex hybrid of *Saccharum* spp.)
7	CP 65-357 (commercial cultivar, a complex hybrid of *Saccharum* spp.)
8	US 84-1034 [=F_1 (CP 63-588 x MN 1500)]
9	US 84-1035 " " " " " "
10	US 84-1036 " " " " " "
11	US 84-1038 [=F_1 (CP 65-357 x MN 1500)]
12	US 84-1063 [=F_1 (CP 65-357 x Mer 81E)]
13	US 84-1064 " " " " " "
14	*Sorghum bicolor* "Mer 81E" (sweet sorghum)
15	*Sorghum bicolor* "MN 1500" (sweet sorghum)

The homogenates were centrifuged at 10,000 g for 15 minutes at 4°C. The supernatants were separated for peroxidase (POD), esterase (EST), glutamate oxaloacetate transaminase (GOT), and glutamate dehydrogenase (GDH) by electrophoresis in a vertical polyacrylamide gel. Concentrations of the separation gel and the space gel were 7.5% and 3.0%, respectively. Two electrode buffers were used. One was a 0.02 M tris/0.0005 M Na_2 EDTA/0.016 M borate buffer at pH 8.3 for EST analysis. The other buffer was tris-glycine buffer at pH 8.3 (0.6 g tris + 2.88 g glycine/1) for POD, GOT, and GDH analyses. Each lane of the gel slab contained 60 ul of enzyme extract. Electrophoresis was carried out at 16.5 v/cm at 4°C for 6 to 8 hours.

Staining for POD and EST was performed as described by Zheng (9). For POD, the gel was stained for 5 to 10 minutes in 100 ml staining buffer which consisted of 70.4 mg ascorbic acid, 20 ml 2% benzidine solution, 20 ml 0.03% hydrogen peroxide, and 60 ml distilled water. The gel was then washed in tap water until the bands for EST became brown. The gel was stained in 100 ml 0.1M phosphate buffer (pH 6.0) containing 0.5 g alpha-naphthyl acetate and 0.5 g beta-naphthyl acetate in acetone for 30 minutes at 37°C, and then 100ml 0.1M phosphate buffer (pH 6.0) containing 0.5g Fast Blue RR salt for 20 minutes. For GOT and GDH, the staining conditions were adopted from Vallejos (6) with a slight modification where the pH value was changed from 8.5 to 7.1 for GOT staining. The staining buffer for GOT was 100 ml 0.1M tris buffer (pH 7.1), 100 mg alpha-Ketoglutarate, 200 mg aspartate, 100 mg 5-phosphopyridoxal, and 150 mg Fast Blue BB salt. After being stained for about 30 minutes, the gel showed red and brown bands. The staining solution for GDH was 100 ml 0.1M tris buffer (pH 7.5), 0.2ml 10mM $CaCl_2$, 800 mg sodium glutamate, 30 mg nicotinamide adenine dinucleotide (NAD), 20 mg NBT (nitro blue tetrazolium), and 4 mg PMS (phenazine methosulfate). The gel was stained in the dark until blue bands appeared.

RESULTS

Peroxidase (POD): The POD banding patterns of the hybrids were different from those of their parents. The hybrids showed the presence of some or all bands of their parents (Fig. 1). The POD bands of the hybrids could be divided into three types: 1. Common bands of both parents, such as bands px-6, px-8, px-14 and px-15; 2. Specific bands of female parents, such as bands px-7, px-10, and px-12 in Uganda and two female sugarcane cultivars, CP 63-588 (without px-12) and CP 65-357; and 3. Specific bands of male parents, such as px-9 and px-11 in SES 314 and band px-18 in two sweet sorghums, MN 1500 and Mer 81E (Table 2). In the intergeneric hybrids of Uganda x SES 314, all three hybrid plants, US 84-1029, US 84-1030 and US 84-1032, had the bands of the three types and any band of either parent could also be found in the hybrids. In commercial sugarcane cultivar x sweet sorghum crosses, three hybrids, US 84-1034, US 84-1035 and US 84-1038, had one of the specific bands, px-16, whereas the other three hybrids, US 84-1036, US 84-1063 and US 84-1064, were without this band. All bands of the female sugarcane parents could be observed in the hybrids, but the male sweet sorghum band px-18 was not present in any of these hybrids. One hybrid, US 84-1034, from a cross between CP 63-588 and MN 1500, showed one hybrid band, px-11 not observed in either parent (Table 2).

Table 2. Number of bands for POD, GOT, and EST in sugarcane hybrids.

Hybrid	POD*				GOT				EST			
	B	F	M	H	B	F	M	H	B	F	M	H
US 84-1029	7	5	2	0	1	8	0	0	8	3	0	1
US 84-1030	7	4	3	0	1	7	0	3	8	3	1	1
US 84-1032	7	5	3	0	1	7	1	3	8	2	0	0
US 84-1034	7	5	1	1	4	4	1	0	4	6	0	0
US 84-1035	9	5	1	0	4	4	0	0	4	6	1	0
US 84-1036	8	5	0	0	4	7	0	0	4	7	0	1
US 84-1038	8	6	1	0	5	3	0	0	4	5	1	1
US 84-1063	8	5	0	0	5	6	0	0	2	7	0	0
US 84-1064	8	5	0	0	5	6	0	0	2	7	0	0

*B: The common bands of both parents.
F: The specific bands of female parent.
M: The specific bands of male parent.
H: The "hybrid band" presents in hybrids only.

Glutamate Oxaloacetate Transaminase (GOT): All materials examined had one common band, GOT-6 (Fig. 2). SES 314 had two specific bands, GOT-11 and GOT-12 while MN 1500 and Mer 81E had one specific band, GOT-14. The GOT banding patterns of these hybrids were more similar to those of the female parents than the male parents. In Uganda x SES 314 cross, one hybrid, US 84-1029, had the same banding pattern as Uganda, but the other two hybrids, US 84-1030 and US 84-1032, had three unique hybrid bands, GOT-5, GOT-7 and GOT-8. However, in commercial sugarcane cultivars x sweet sorghum crosses, both female and male parents possessed four additional common bands, GOT-1, GOT-13, GOT-15 and GOT-16 (CP 63-588 was without GOT-13). US 84-1034, US 84-1035, and US 84-1038 appeared to have very similar GOT patterns. The isozyme bands, GOT-3, GOT-5, GOT-7 and GOT-8 were missing from the banding pattern of female parent, CP 63-588. US 84-1036 had the same banding pattern of CP 63-588 as did US 84-1063 and US 84-1064 with their female parent, CP 65-357.

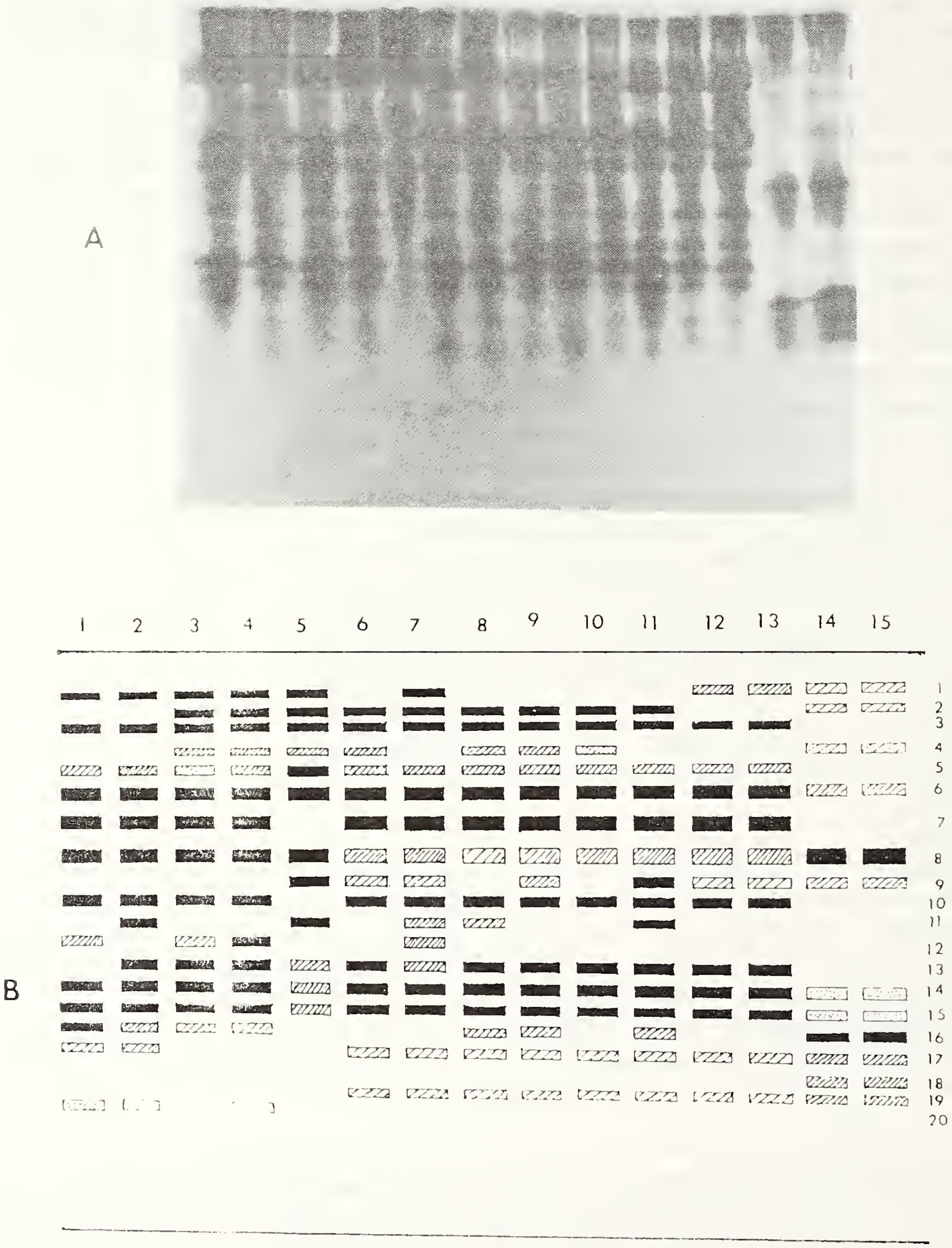

Fig. 1 The zymogram patterns of peroxidase (POD) in leaves of Saccharum, Erianthus, and Sorghum and their hybrids. The designation of the clone number is shown in Table 1. A: photogram; B: Diagram.

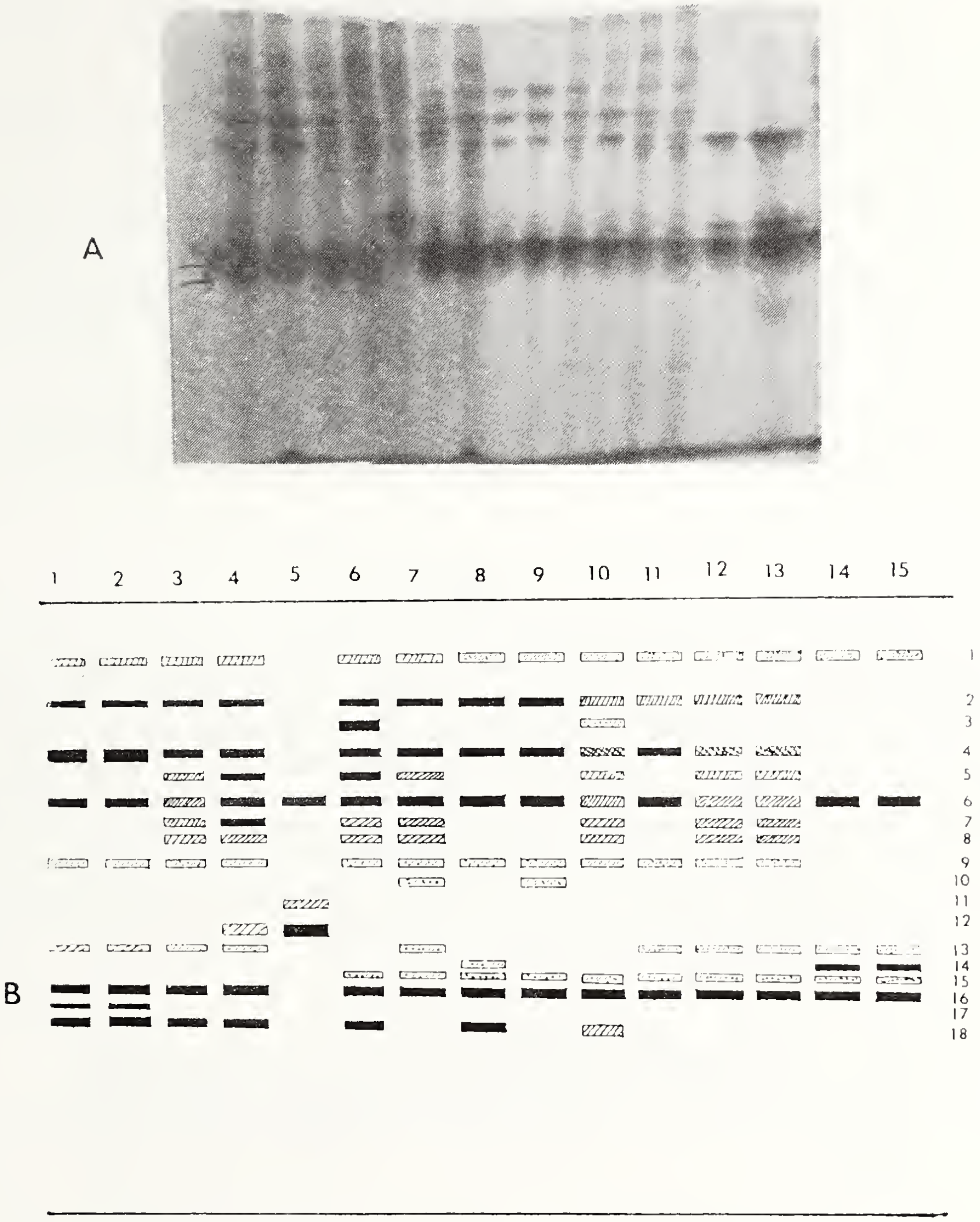

Fig. 2. The zymogram patterns of glutamate oxaloacetate transaminase (GOT) in leaves of Saccharum, Erianthus, and Sorghum, and their hybrids. The designation of the clone number is shown in Table 1. A: Photogram; B: Diagram.

Esterase (EST): Only one common band (EST-19) appeared in all materials analyzed (Fig. 3). The EST banding pattern of Uganda was very similar to that of SES 314 and both of them also showed a banding pattern very similar to that of commercial sugarcane cultivars, CP 63-588 and CP 65-357. They had six common bands (EST-12, 13, 18, 19, 20 and 23). However, the EST banding patterns were markedly different between sugarcane cultivars and sweet sorghums with only two common bands (EST-6 and EST-19). Two sweet sorghum cultivars also had differences between their banding patterns. In Uganda x SES 314 crosses, all three hybrids, US 84-1029, US 84-1030 and US 84-1032, had a very similar banding pattern and showed two female-specific bands (EST-21 and EST-27). One female band, EST-6, appeared in US 84-1029 and US 84-1030, but it was missing in US 84-1032. One male-specific band (EST-24) appeared only in US 84-1030. Both US 84-1029 and US 84-1030 had one hybrid band (EST-5) which appeared in sugarcane cultivars and their hybrids except US 84-1063 and US 84-1064. In sugarcane cultivar x sweet sorghum crosses, five female-specific bands (EST-5, 10, 14 and 18) appeared in the hybrids. The female-specific band, EST-16, was missing in US 84-1036 and EST-10 was missing in both US 84-1034 and US 84-1035. Two male-specific bands, EST-1, appeared in US 84-1035 and EST-25 did not appear in any hybrid. One hybrid band (EST-28) appeared in US 84-1036 and US 84-1038 to be a common band in Uganda, SES 314 and their hybrids, but missing in sugarcane, sweet sorghum and most of their hybrids.

Glutamate Dehydrogenase (GDH): All parents and their hybrids examined showed a simple GDH band in the same position on the gel slab except SES 314 which appeared to have the band with slightly lower mobility.

DISCUSSION

Polyacryamide gel electrophoresis gave good separation of peroxidase, glutamate oxaloacete transaminase, and esterase. These enzymes could be used to identify some of the hybrids from crosses between *Saccharum* and its related genera. All hybrids except US 84-1063, US 84-1064, and US 84-1036 possessed specific bands of both female and male parents and some of these hybrids had hybrid bands. These results indicate that some plants were true hybrids. These exceptional plants could be products of self-pollination of the female parent (CP 65-357). The sugarcane x sorghum hybrid plants appeared to have relatively small stalk diameter, profuse tillering and sprouted buds on the stalk. These morphological characteristics plus isozyme analysis facilitate positive identification of sugarcane x sorghum hybrids.

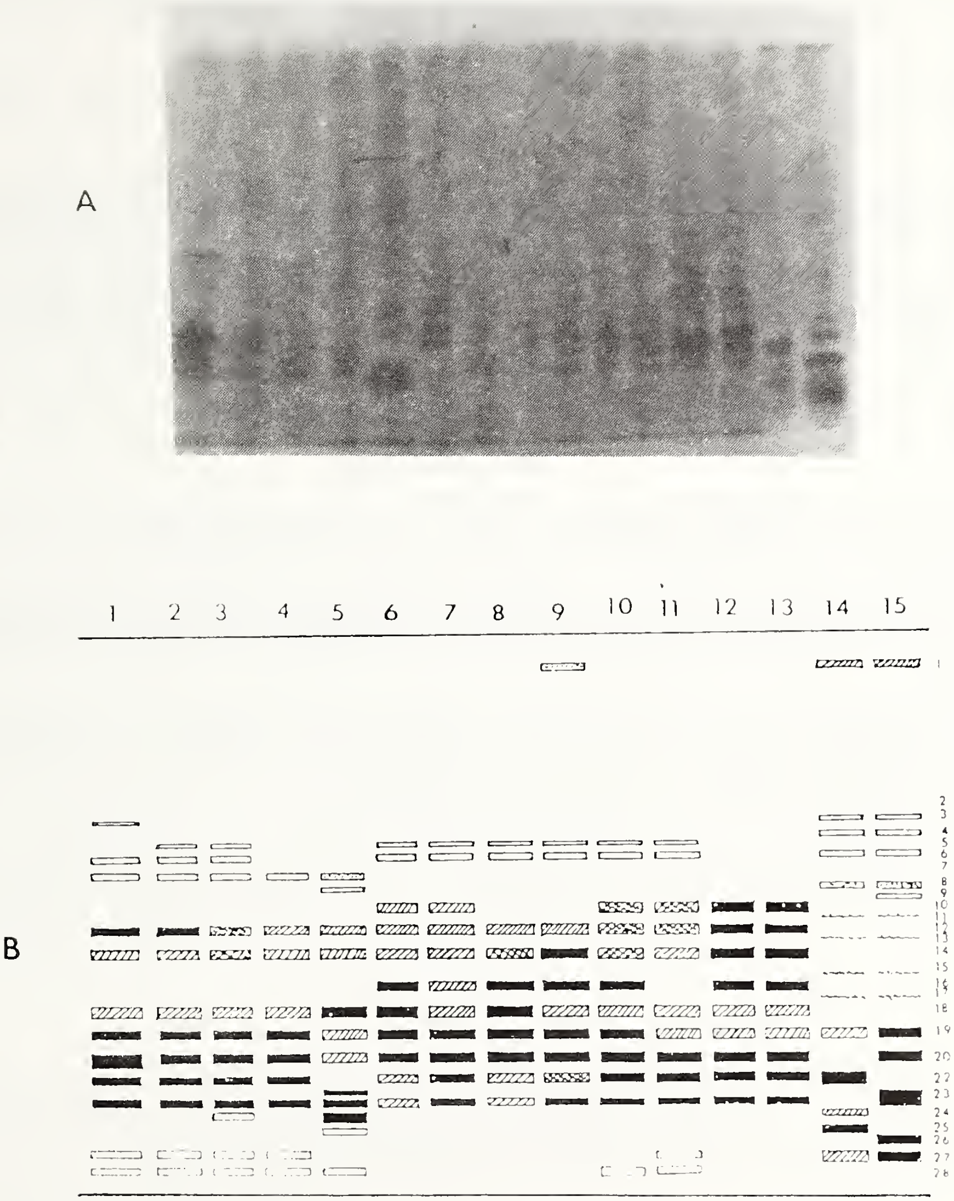

Fig. 3. The zymogram pattern of esterase (EST) in leaves of Saccharum, Erianthus, and Sorghum, and their hybrids. The designation of the clone number is shown in Table 1. A: Photogram; B: Diagram.

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ANALYSIS OF MOLASSES AND SUGAR BY YSI 2700 SELECT
AN INTER-LABORATORY STUDY

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ABSTRACT

Commercial enzyme based sugar analyzers have been on the market for a number of years. They have found application primarily in the clinical market. Because this type of instrument offers great potential for simplifying sugar analysis an inter-laboratory study was undertaken to determine the repeatability of analysis of the newest generation of this class of instrument. The results of this study indicate that the instrument is a useful adjunct for process laboratories but does not have the requisite precision to replace standard methods.

INTRODUCTION

The Yellow Springs Instrument Co., Inc (YSI) Model 2700 Select biochemistry analyzer is the latest in a series of immobilized enzyme based sugar analyzers. This instrument rapidly measures analytes and requires little or no sample preparation. As a class, these instruments have been previously studied for potential use in the sugar factory analytical laboratory (3). This specific instrument is making some inroads into the cane sugar industry and is currently a major analytical tool in the factory laboratory of a US sugar producer (1). However, a detailed, systematic analysis as to the utility of this instrument in the sugar factory laboratory has not been conducted. The interest of the sugar industry in this analyzer lies in its ability to directly measure sucrose and glucose. The Model 2700 Select does not analyze for fructose. The company claims that its measurements are virtually unaffected by color, turbidity, density, viscosity, pH, volatility, specific gravity, temperature, index of refraction, optical activity or the presence of proteins or other biochemicals. In order to determine the repeatability of analyses of raw sugar and final molasses a comparative inter-laboratory study was conducted.

METHODS

Participating Laboratories: - Four laboratories participated in this study. They were: [1] The Audubon Sugar Institute, Louisiana State University Agricultural Experiment Station, Baton Rouge, La. [2] The USDA Sugar Cane Research Laboratory, Houma, La. [3] The US Sugar Corporation Factory Laboratory, Clewiston, Fla. and [4] the Institute fur Landwirtshaftliche Technologie und Zukerindustrie, Braunschweig, Germany.

Purpose and Extent - The purpose of this study was to test the inter-laboratory variation of the YSI 2700 Select in the analysis of molasses and raw sugar. Identically equipped instruments were supplied to the participating laboratories courtesy of YSI. Eight final molasses samples and seven raw sugar samples obtained from Louisiana sugar mills were supplied to participating laboratories. These samples were analyzed by traditional methods, HPLC and YSI 2700 Select before being distributed to the participating laboratories.

Sample Preparation: Procedures (As distributed to participating laboratories)

Molasses: Prepare a 1:1 dilution by weight. Then weigh 10.0 gms of this molasses/water dilution into a 100 ml volumetric flask and dilute to 100 ml with water. Prepare triplicates of this final dilution.

Sugar: Dissolve 2.5 gms of raw sugar in water and make up to volume with water in a 100 ml volumetric flask. Prepare triplicates.

YSI Analysis - Analyses were conducted according to manufacturer's directions. The parameters for setting up the Model 2700 Select (Table 1) were sent to each of the participating laboratories along with the samples. Each analysis was repeated five times. Brix determinations were conducted by refractometry.

Table 1

Instrument Setup Parameters

Sample Size	25UL
Calibration Method	Two Station
BLACK PROBE - SUCROSE	
Calibrator	5000mg/l
End Point	30 sec
WHITE PROBE - DEXTROSE	
Calibrator	2500mg/l
End Point	30 sec
AUTOCAL	
Temperature	1°C
Calibration shift	2%

Statistical Evaluation - "Given *kn* experimental units that can be grouped into *n* blocks of *k* units each in such a way that the responses of the units within a block may be expected to be more homogenous than those of units taken from *different* blocks, we may use a *randomized complete block* design for an experiment involving *k* treatments" (5).

There is a common source for each of the final molasses and raw sugars. Each sample was mixed and subdivided into four parts. Each batch of molasses or sugar was considered as a block. We assumed homogeneity within a batch of molasses or sugar but not across batches of molasses or sugar. Triplicate dilutions were made of each analytical subsample and five readings were taken on each triplicate. There were fifteen readings per sample per laboratory. The average of these fifteen readings was calculated to give one value per sample per laboratory for statistical analysis.

Our primary interest was in detecting differences in measurement between the four laboratories so each lab was used as a fixed effect treatment and the hypothesis was

H_0: $u1 = u2 = u3 = u4$
H_1: not H_0

where u1, u2, u3, and u4 were the values of each of the four laboratories respectively.

The alpha value, the standard by which one accepts or rejects the hypothesis H_0 is 0.05. If H_0 was rejected in favor of H_1 the Bonferroni pairwise comparison was used to avoid inflation of Type 1 error. As there were at least six comparisons the alpha value of 0.01 was conservative. If the P value (which indicates the strength of significance) was > alpha (0.01) then the conclusion was

Mean of Lab (i) = Mean of Lab (j)

where lab i and j are different laboratories. However if the P value was < alpha (0.01) then the values were not equivalent.

Additional calculations were made to obtain reproducibility and repeatability parameters. Variance and maximum tolerable differences (reproducibility value and repeatability value) are as defined by Horwitz (4). The following symbols were used: repeatability (s_r), reproducibility (s_R), repeatability value ($r = 2.8 \times s_r$), reproducibility value ($R = 2.8 \times s_R$).

RESULTS AND DISCUSSION

Comparisons of Methods

Samples were first analyzed by the YSI Model 2700 Select and then results compared to HPLC (6) and pol values. Pol analysis was conducted using the lead substitution method (2). The P values for sucrose analysis showed an equivalence of methods for raw sugar analysis (Table 2) but not for molasses analysis (Table 3). Pol analysis of the test samples (Table 4) was used as the basis for comparison with the YSI analysis.

Table 2

Sucrose in Sugar by Different Methods
P Values

Method	YSI	POL	HPLC
YSI	.	0.1228	0.3153
POL	.	.	0.5519

P = strength of significance, a $P > 0.05$ indicates equivalence

Table 3

Sucrose in Molasses by Different Methods
P Values

Method	YSI	POL	HPLC
YSI	.	0.001	0.0076
POL	.	.	0.001

Table 4

Sucrose Analysis (Pol) of Test Samples
(% by weight)

Sample	Raw Sugar	Molasses
A	97.47	30.96
B	97.50	33.36
C	97.93	26.60
D	97.87	24.88
E	97.48	27.60
F	97.21	27.36
G	95.79	23.36
H	-	30.08

Sucrose Analysis by YSI

Two of the four reporting laboratories reported values for sucrose standards with a variation greater than 5%, even though all other instrument parameters were identical. Therefore, the sucrose values reported by these laboratories were corrected according to the equivalent standard values obtained from the other laboratories. The averages of each set of fifteen readings were used to calculate means. A summary of the means and variations for raw sugar are given in Table 5 and for molasses in Table 6. The repeatability of sucrose analysis in raw sugar ranged from 1.79 to 5.51% and the reproducibility ranged from 6.59 to 12.52%. The repeatability for sucrose analysis in molasses ranged from 2.91 to 5.27% and the reproducibility ranged from 4.85 to 16.3%.

Table 5

Sucrose (%) in Raw Cane Sugar

	A	B	C	D	E	F	G
Mean	97.35	97.04	96.00	98.10	96.38	97.12	96.66
s_r	1.03	0.62	1.00	1.04	1.90	1.35	0.78
s_R	2.30	2.82	2.26	3.90	4.31	4.01	3.23
r	2.88	1.74	2.80	2.88	5.32	3.78	2.18
R	6.44	7.90	6.33	10.90	12.07	11.23	9.04

Symbols: repeatability (s_r), reproducibility (s_R), repeatability value ($r = 2.8 \times s_r$) reproducibility value ($R = 2.8 \times s_R$).

Table 6

Sucrose (%) in Cane Molasses

	A	B	C	D	E	F	G	H
Mean	35.20	35.86	30.89	30.70	32.56	30.89	32.20	34.70
s_r	0.40	0.52	0.58	0.58	0.47	0.32	0.45	0.45
s_R	2.05	0.62	1.31	0.86	0.72	0.63	1.02	0.98
r	1.12	1.46	1.62	1.62	1.32	0.90	1.26	1.26
R	5.74	1.74	3.67	2.41	2.02	1.76	2.90	2.74

Symbols: repeatability (s_r), reproducibility (s_R), repeatability value ($r = 2.8 \times s_r$) reproducibility value ($R = 2.8 \times s_R$).

Inter-laboratory Analysis of Variance

A matrix of P values for molasses analysis is shown in Table 7. The hypothesis H_0 is acceptable i.e. that the sucrose values as measured between laboratories are equivalent. The hypothesis H_0 for sugar is rejected (Table 8). However, for pairwise comparisons the following can be accepted

Mean of Lab (1) = Mean of Lab (3)
Mean of Lab (2) = Mean of Lab (4)
Mean of Lab (1) = Mean of Lab (2)

Table 7

Sucrose in Cane Molasses Inter-Laboratory Variance

P Values

Laboratory	1	2	3	4
1	.	0.5285	0.1137	0.2248
2	.	.	0.0324	0.0724
3	.	.	.	0.6932

Table 8

Sucrose in Cane Sugar Inter-Laboratory Variance

P Values

Laboratory	1	2	3	4
1	.	0.0117	0.6435	0.0001
2	.	.	0.0042	0.0640
3	.	.	.	0.0001

CONCLUSION

The repeatability of the YSI 2700 Select falls within the 5% range quoted by the manufacturer for sucrose analysis in both sugar and molasses. However, the inter-laboratory variance was well above the 5% level producing an unacceptable level of reproducibility for analysis of the sample materials. There did not seem to be any significant difference in the ability of the instrument to handle either raw sugar or molasses samples. Given the ease of use of this instrument and the repeatability of analysis in the laboratory it promises to be an excellent instrument for factory control. Because of the low reproducibility it should not be used where financial (payment) transactions are involved.

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JOHNSONGRASS (*SORGHUM HALEPENSE*) CONTROL IN SUGARCANE WITH SELECTED PREEMERGENCE AND POSTEMERGENCE HERBICIDES[1]

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ABSTRACT

The number of herbicides labelled for the control of johnsongrass within sugarcane is limited. Experimental compounds and herbicides registered for use in other crops were evaluated in field studies for their ability to selectively control johnsongrass in sugarcane. When applied in early spring, postemergence to the crop and preemergence to seedling johnsongrass, imazapyr at 0.15 kg ha^{-1}, AC 263,222 at 0.22 kg ha^{-1}, clomazone at 2.24 kg ha^{-1}, fomesafen at 0.56 kg ha^{-1}, and tank mixtures of pendimethalin plus atrazine at 2.24 plus 2.13 kg ha^{-1} and prodiamine plus atrazine at 1.68 plus 2.13 kg ha^{-1} provided excellent control of seedling johnsongrass. Cane and sugar yields following these treatments were equivalent to those obtained with metribuzin and terbacil standards. Postemergence control of rhizomatous johnsongrass in second-ratoon sugarcane crops with nicosulfuron and primisulfuron was compared to standard postemergence applications of asulam. Averaged over the three studies, asulam applied at 3.74 kg ha^{-1} in April provided 78% control of johnsongrass 4 wk after treatment (WAT) and increased sugar yields by an average of 117% over the untreated check. Johnsongrass control with nicosulfuron was higher than with primisulfuron in two studies where rate comparisons were made. Late-season johnsongrass control, based on panicle numbers, indicated that nicosulfuron at 0.03 kg ha^{-1} was as effective as asulam at 3.74 kg ha^{-1}. Despite some early-season crop injury following treatment with nicosulfuron at 0.03 kg ha^{-1}, nicosulfuron controlled johnsongrass well enough to produce yields of sugar equivalent to those obtained with asulam at 3.74 kg ha^{-1}. *Nomenclature*: AC-263,222, (±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxy-1*H*-imidazol-2-yl]-5-methyl-3-pyridinecarboxylic acid; asulam, methyl[(4-aminophenyl) sulfonyl]carbamate; atrazine, 6-chloro-*N*-ethyl-*N'*-(1-methylethyl)-1,3,5-triazine-2,4-diamine; clomazone, 2-[(2-chlorophenyl)methyl-4,4 dimethyl-3-isoxazolidinone; fomesafen, 5-[2-chloro-4-(trifluromethyl)phenoxyl]-*N*-(methylsulfonyl)-2-nitrobenzamide; imazapyr, (±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-pyridinecarboxylic acid; metribuzin, 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5 (4*H*)-one; nicosulfuron, 2-[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]-carbonyl]amino]sulfonyl]-*N,N*-dimethyl-3-pyridincarboxamide; pendimethalin, N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine; primisulfuron, 2-[[[[[4,6-bis (difluoromethoxy)-2-pyrimidinyl]amino]carbonyl]amino]sulfonyl] benzoic acid; prodiamine, 2,4-dinitro-*N,N*-dipropyl-6-(trifluoromethyl)-1,3-benzenediamine; terbacil, 5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4-(1*H*,3*H*)-pyrimidinedione; sugarcane, a complex interspecific hybrid of *Saccharum* spp. 'CP 65-357' and 'CP 70-321'; johnsongrass, *Sorghum halepense* (L.)Pers.

Additional index words. AC 263,222, asulam, atrazine, clomazone, fomesafen, imazapyr, metribuzin, nicosulfuron, pendimethalin, primisulfuron, prodiamine, quinclorac, terbacil, *Saccharum* spp., *Sorghum halepense* (L)Pers.

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INTRODUCTION

Johnsongrass is a major weed of sugarcane in Louisiana. Surface applications of either metribuzin, terbacil, or a tank mixture of pendimethalin[2] plus atrazine are applied each spring for the duration of the 3-yr crop cycle to control seedling johnsongrass (6). The spring treatments are generally applied in March after the emergence of the primary shoots of sugarcane but prior to the emergence of seedling johnsongrass.

Several soil-surface applied herbicides registered for use in annual crops and in noncropland situations have been shown to be nonphytotoxic to sugarcane in preliminary screening trials (3, 4). These herbicides provide preemergence control of johnsongrass at rates significantly lower than the rates of currently used herbicides.

Asulam is the only herbicide registered for the postemergence control of johnsongrass in sugarcane (6). The effectiveness of asulam in destroying johnsongrass rhizome buds is affected by the extensiveness of the rhizome system and the number of applications (7, 8, 12). Two sulfonylurea herbicides, nicosulfuron and primisulfuron, are registered for postemergence control of johnsongrass in corn (*Zea mays* L.) (1, 2). They have also shown some potential for postemergence control of itchgrass (*Rottboellia cochinchinensis* Clayon (Lour.)), another problem weed of sugarcane in Louisiana (5). The effectiveness of these herbicides in controlling rhizome johnsongrass in sugarcane, as well as their potential phytotoxic effects to the crop, have not been fully determined. The objective of these studies was to compare the effectiveness of selected preemergence and postemergence herbicides to those currently registered for the control of johnsongrass in sugarcane.

MATERIALS AND METHODS

Preemergence studies

Studies were conducted in 1987 to compare AC 263,222 and imazapyr in a plant-cane (study A) and a first-ratoon (study B) field of sugarcane. The fields were located on Mhoon silt loam (fine-silty, mixed, nonacid, thermic, Typic Fluvaquents) soils and were planted to the cultivars CP 70-321 (study A) and CP 65-357 (study B). In study A, the field had no preemergence herbicide treatment after the crop was planted in September, 1986. Row tops were freed of winter-killed and green crop and weed vegetation by removing 1 to 2 cm of soil from the row tops with a revolving disk blade on March 13, 1987. After removing the soil from the row top, the row sides were cultivated. The soil on top of each row was loosened with three passes of a rolling tooth cultivator (Lilleston type-Lely Roterra[3]) to stimulate crop emergence and weed seed germination just prior to herbicide application on March 23. At the time of treatment, most sugarcane shoots had two leaves and averaged 11 cm tall when measured from the soil surface to the tip of the longest leaf.

Herbicide treatments were applied with a tractor-mounted, roller-pump pressurized, sprayer calibrated to deliver an aqueous carrier volume of 374 L ha^{-1}. The herbicides were applied on a 90-cm band using three flat-fan nozzles per row. In this configuration, a nozzle was mounted to the spray boom directly over the center of the row. Boom height was adjusted so that the nozzle sprayed the entire 90-cm width. The remaining nozzles were mounted 30-cm to either side of the center nozzle on 30-cm drops. The outside nozzles were angled inward so that each sprayed 60-cm of the 90-cm band when measured from the outside of the band.

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[2] Pendimethalin usage in sugarcane grown in Louisiana was allowed in 1991 and 1992 under an EPA-issued section 18 label. EPA granted a full label (EPA Registration Number 241-337) for spring applications of pendimethalin in sugarcane on February 25, 1993.

[3] The use of trade names in this publication does not constitute a guarantee, warranty, or endorsement of the product by the U.S. Dept. of Agric. or the Louisiana Agric. Exp. Stn.

In study B, the row sides were off-barred and the rows reformed on March 25. Winter-killed and green crop and weed vegetation was not removed from the top of the row because more than 75% of the soil surface was exposed to the spray droplets. Treatments were applied on April 7, postemergence to the sugarcane and preemergence to the warm-season seedling weeds, using the sprayer described above. At the time of treatment, most sugarcane shoots had three leaves and averaged 69 cm tall.

Plant-cane fields of CP 65-357 also growing on Mhoon silty clay loam soils and having histories of johnsongrass infestations were selected for studies C (1989) and D (1990). Three days prior to the anticipated treatment date, row sides were cultivated and a rolling tooth cultivator was passed twice over the 60-cm wide sugarcane drill in opposite directions as described above. Herbicides were applied postemergence to sugarcane but preemergence to seedling weeds on March 21, 1989 (study C) and March 14, 1990 (study D). Herbicides were applied on a 90-cm band on top of the sugarcane row at an aqueous carrier volume of 187 L ha^{-1} using a three-nozzle per band, tractor-mounted, compressed air pressurized sprayer. The nozzle arrangement on the spray boom was similar to that described above. At the time of treatment, most sugarcane shoots had three leaves and averaged 38 cm (study C) and 72 cm (study D) tall.

Postemergence studies

Second-ratoon fields of sugarcane, CP 65-357, growing on silt-loam soils and infested with rhizomatous johnsongrass were selected in 1988 and 1989. The johnsongrass present in these studies had developed over the previous two growing seasons of the 3-yr crop cycle. Study E (1988) and study F (1989) were located in Terrebonne Parish and study G (1989) was located in Iberville Parish, approximately 100 km northwest of Terrebonne Parish.

Herbicide treatments were applied postemergence to sugarcane and johnsongrass on a 90-cm band at aqueous carrier volumes of 374 L ha^{-1} (study E) or 187 L ha^{-1} (studies F and G). Treatment solutions contained nonionic surfactant[4] at either 0.25% (study E), or 0.5% (study F) or crop-oil concentrate[5] at 1% by volume (study G). Johnsongrass and sugarcane in study E averaged 56 and 61 cm tall for the April 14 application and 102 and 84 cm tall for the May 4 applications, respectively. On the May 4 application date, the majority of the johnsongrass had emerged flag leaves. In study F, treatments were applied on April 7 when johnsongrass averaged 46 cm tall and sugarcane averaged 61 cm tall and on May 4 when johnsongrass and sugarcane both averaged 90 cm. At the time of the May 4 application, approximately 60% of the johnsongrass culms had emerged flag leaves. Rainfall totalling 1.9 cm fell within 8 h of the May 4 application of study F. In study G, treatments were applied on May 1 when johnsongrass was 56 cm tall and sugarcane was 38 cm tall.

Practices common to all studies

The row sides were cultivated at timely intervals with disk cultivators and the crops were fertilized using standard practices. Untreated soil was not placed on top of the treated band until the layby (final) cultivation in late May or early June when 2 to 5 cm of soil was placed on top of the row. Fields received a preemergence application of atrazine at 2.24 kg ha^{-1} as a broadcast spray directed under the crop's canopy immediately following the layby cultivation.

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[4] Triton AG-98 (composed of alkylarylpolyoxyethylene glycols). Rohm and Haas Co., Independence Mall West, Philadelphia, PA 19105.

[5] Agri-Dex (contains 83% paraffinic mineral oil and 17% polyoxyethlene sorbitan fatty acid esters); from Helena Chemical Co., 5700 Poplar St., Memphis, TN 38137.

Visual estimates of herbicidal effects on johnsongrass and sugarcane were made 4 and/or 8 WAT. Estimates of leaf discoloration and reductions in shoot height and shoot numbers were based on a percentage scale of 0 to 100 with 0 representing no injury and 100 representing kill. In studies C and D, johnsongrass control 8 WAT was based on the number of johnsongrass plants in each plot. The number of harvestable stalks of sugarcane and their heights were determined on September 9 (study A), September 11 (study B), August 17 (study C), September 5 (study D), September 6 (study E), August 30 (study F), and September 26 (study G). To be considered harvestable, stalks had to measure at least 1.4 m when measured from the soil surface to the triangular shaped hinge in the collar region of the youngest leaf below the whorl. Late-season johnsongrass control was determined by counting the number of johnsongrass panicles in each plot on the same date that the numbers and heights of millable sugarcane stalks were determined.

Plots were mechanically harvested on November 23 (study A), November 9 (study B), December 4 (study C), November 27 (study D), December 6 (study E), October 28 (study F) and November 30 (study G). Harvested stalks were burned to remove most of the extraneous leaf material and then weighed to determine gross cane yields. A sample consisting of 15 randomly-selected stalks was removed from each plot, weighed to determine stalk weight, and crushed in a three-roller mill. The extracted juice was analyzed for Brix and sucrose to estimate its theoretically recoverable sugar (TRS) content as described previously (11). Sugar yields are the product of gross cane yields and TRS contents.

The experiments were arranged in randomized complete block designs with six (studies A, B, C, D, E and F) or four (study G) replications of each treatment. Individual plots consisted of three adjacent, 1.8-m wide rows 12.2 (studies A and B), 15.2 (studies C, D, E and F) or 10.7 (study G) m long. Data for each study were subjected to analyses of variance. Where appropriate, across year analyses of data were performed and if interactions were not detected, data were pooled. Means were separated at the 0.05 level of probability using Fisher's Protected LSD tests.

RESULTS AND DISCUSSION

Preemergence studies

Johnsongrass infestation levels in the untreated plots of study A were late in developing, light, and variable; therefore, no ratings of johnsongrass control were made. Sugarcane injury in the form of reductions in shoot height and number was evident 4 WAT in plots treated with imazapyr and AC 263,222 (Table 1). This injury was higher than the terbacil and pendimethalin plus atrazine standards where imazapyr was applied at 0.56 kg ha^{-1} or higher and where AC 263,222 was applied at 0.45 kg ha^{-1}. By 8 WAT sugarcane injury was higher than the standard treatments only where imazapyr was applied at 0.84 kg ha^{-1} or higher.

Use of either terbacil or a tank mixture of pendimethalin plus atrazine did not result in an increase in stalk numbers over the untreated check because weed infestations developed late in the growing season (Table 1). Reductions in stalk numbers occurred only where imazapyr was applied at rates of 1.40 and 1.68 kg ha^{-1} when compared to the plots receiving terbacil. Where imazapyr was applied at rates of 1.12 kg ha^{-1} or higher, leaf and nodal numbers appeared to be similar to the untreated check, but leaf and internode lengths were severely reduced. As a result of this injury, stalk heights and weights were lower than the terbacil treatment when imazapyr was applied at rates of 1.12 kg ha^{-1} or higher (Table 1).

The reductions in stalk numbers and stalk weights associated with the use of imazapyr at rates in excess of 0.84 kg ha^{-1} resulted in lower yields of cane than the terbacil standard. Yields of cane were similar to the terbacil standard where AC 263,222 was applied despite the early injury. TRS values did not appear to be affected by imazapyr when compared to the terbacil standard. As a result, sugar yields reflected reductions in cane yields associated with the use of imazapyr (Table 1).

Table 1. The effects of preemergence applications of imazapyr and AC 263,222 on a plant-cane crop of sugarcane. Study A.

		Crop injury[1]		Stalk			Yield	
Herbicide(s)	Rate(s)	4	8	no.	wt.	TRS[2]	cane	sugar
	(kg ha^{-1})	— (%) —		(no. ha^{-1} x 10^{3})	(kg)	(kg Mg^{-1})	(Mg ha^{-1})	
Imazapyr	0.15	13	9	78	1.12	116	86	9.9
Imazapyr	0.28	12	10	76	1.09	118	80	9.3
Imazapyr	0.56	28	18	78	1.09	116	79	8.9
Imazapyr	0.84	33	22	75	1.01	112	74	8.2
Imazapyr	1.12	42	38	71	0.96	112	66	7.3
Imazapyr	1.40	55	49	49	0.84	109	51	5.5
Imazapyr	1.68	50	42	64	0.87	114	55	6.2
AC 263,222	0.11	9	8	77	1.12	115	79	8.9
AC 263,222	0.22	13	14	80	1.07	117	89	10.2
AC 263,222	0.45	34	13	79	1.05	116	83	9.4
Pendimethalin + Atrazine	2.24 + 3.20	9	9	75	1.09	116	75	8.6
Terbacil	2.13	4	7	76	1.11	116	80	9.2
Untreated	—	—	—	71	1.11	118	76	8.8
LSD (0.05)		11	13	11	0.14	5	10	1.2

[1] Visual estimates of sugarcane injury were made 4 and 8 wks after treatment.

[2] TRS, theoretically recoverable sugar.

With the exception of AC 263,222 at 0.11 kg ha^{-1}, all of the treatments controlled johnsongrass at levels equivalent to terbacil through 8 WAT in study B (Table 2). Sugarcane injury in the form of shoot height and population reductions was observed 4 WAT in plots treated with imazapyr and AC 263,222. Sugarcane injury 8 WAT was higher than that observed with the terbacil standard with imazapyr at rates of 0.28 kg ha^{-1} and higher and with AC 263,222 at 0.22 and 0.45 kg ha^{-1}. The plant-cane crop of sugarcane in Louisiana exhibits the greatest sensitivity to herbicide injury (9, 11). In these studies, the first-ratoon crop may have been more sensitive to imazapyr and AC 263,222 because the two cultivars, CP 70-321 and CP 65-357, differed in sensitivity as previously observed with other herbicides (9, 11) and/or because the removal of crop vegetation prior to treatment of the plant-cane crop of CP 70-321 (study A) limited the foliar absorption of herbicide. In the first-ratoon crop of CP 65-357 (study B) potentially phytotoxic levels may have accumulated faster because the herbicides could be absorbed by both the roots and the leaves.

As a result of the earlier injury, sugarcane stalk numbers and weights were lower than the standard pendimethalin plus atrazine and terbacil treatments where imazapyr was applied at 0.56 kg ha^{-1} and higher (Table 2). The shortened internodes and leaves observed in plots treated with imazapyr in study A were also observed in study B. In this study, TRS contents were lower than the two standard treatments where imazapyr was applied at rates of 0.28 kg ha^{-1} and higher. AC 263,222 did not injure sugarcane severely enough to cause a reduction in stalk numbers; however, stalk weights were lower than the two standard treatments when AC 263,222 was applied at 0.45 kg ha^{-1}. Reductions in stalk numbers and stalk weights following treatment with imazapyr were reflected as lower cane yields, particularly when the imazapyr rate exceeded 0.28 kg ha^{-1} (Table 2). Cane yields were similar to the untreated check and the two standard treatments where AC 263,222 was applied even at 0.45 kg ha^{-1}. Sugar yield, which is the product of the yield of cane and TRS, reflected a further reduction associated with the injurious effects of imazapyr.

Table 2. The effects of preemergence applications of imazapyr and AC 263,222 on johnsongrass control in a first-ratoon crop of sugarcane. Study B.

Herbicide(s)	Rate(s)	JG control[1] 4	JG control[1] 8	SC injury[1] 4	SC injury[1] 8	Stalk no.	Stalk wt.	TRS[2]	Yield cane	Yield sugar
	(kg ha^{-1})	(%)				(no. ha^{-1} x 10^3)	(kg)	(kg Mg^{-1})	(Mg ha^{-1})	
Imazapyr	0.15	97	86	21	16	70	0.93	125	76	9.3
Imazapyr	0.28	96	91	34	40	66	0.85	121	65	7.8
Imazapyr	0.56	99	98	44	68	50	0.68	119	48	5.6
Imazapyr	0.84	97	99	55	77	43	0.61	118	38	4.4
Imazapyr	1.12	99	99	52	80	32	0.57	114	31	3.5
Imazapyr	1.40	99	99	57	85	25	0.59	116	29	3.3
Imazapyr	1.68	99	99	57	87	20	0.52	117	22	2.6
AC 263,222	0.11	86	77	16	7	69	0.90	127	71	8.9
AC 263,222	0.22	98	88	33	27	69	0.87	126	72	8.9
AC 263,222	0.45	99	96	38	48	71	0.81	124	70	8.5
Pendimethalin + Atrazine	2.24 + 3.20	91	88	0	2	69	0.94	129	74	9.3
Terbacil	1.9	89	91	2	11	65	0.93	128	70	8.8
Untreated	—	—	—	—	—	66	0.91	130	75	9.6
LSD (0.05)		7	9	9	6	7	0.09	4	7	0.8

[1] Visual estimates of johnsongrass (JG) control and sugarcane (SC) injury were made 4 and 8 wks after treatment.

[2] TRS, theoretically recoverable sugar.

The results of studies C and D were combined because the year effect was not significant. Seedling johnsongrass emergence did not occur until after the 4 WAT rating in both years, hence, differences in johnsongrass control between the various treatments could not be determined until 8 WAT. Standard treatments of metribuzin and terbacil provided excellent control of seedling johnsongrass 8 WAT (Table 3). The mixture of pendimethalin plus atrazine at 3.36 plus 2.13 kg ha^{-1} controlled johnsongrass equivalent to the standard rates of metribuzin and terbacil. However, when the mixture was applied at 2.24 plus 2.13 kg ha^{-1} johnsongrass control was lower than that observed with metribuzin and terbacil. Prodiamine at 1.68 kg ha^{-1} was as effective as pendimethalin at 2.24 kg ha^{-1} in controlling johnsongrass. Quinclorac (3,7-dichloro-8-quinolinecarboxylic acid) and atrazine did not provide acceptable (>80%) levels of johnsongrass control 8 WAT. The poor control of johnsongrass with quinclorac was still evident late in the season when johnsongrass panicles were counted.

Table 3. The effect of selected preemergence herbicides on johnsongrass (JG) and sugarcane. Studies C and D combined.

Herbicide(s)	Rate(s)	Rating[1] SC	Rating[1] JG	JG panicles	Stalk no.	Stalk wt.	TRS[2]	Cane yield
	(kg ha^{-1})	— (%) —		(no. ha^{-1} x 10^3)		(kg)	(kg Mg^{-1})	(Mg ha^{-1})
Clomazone	1.12	6	93	10	64	1.19	127	79
Clomazone	1.68	7	87	6	63	1.15	128	78
Clomazone	2.24	9	97	4	64	1.15	128	82
Clomazone + Atrazine	1.12 + 2.13	8	97	7	63	1.16	129	78
Fomesafen	0.56	3	94	4	64	1.14	129	79
Fomesafen	0.84	3	98	2	68	1.17	128	79
Fomesafen	1.12	6	90	3	62	1.16	128	75
Quinclorac	0.28	1	34	35	62	1.19	130	77
Quinclorac	0.56	0	44	34	63	1.17	130	77
Quinclorac	1.12	1	38	35	62	1.18	129	75
Prodiamine + Atrazine	1.68 + 2.13	2	97	4	67	1.17	128	84
Prodiamine + Atrazine	2.24 + 2.13	3	97	2	62	1.23	127	83
Prodiamine + Atrazine	2.80 + 2.13	1	98	3	62	1.22	128	83
Pendimethalin + Atrazine	2.24 + 2.13	0	80	9	66	1.22	128	83
Pendimethalin + Atrazine	3.36 + 2.13	2	93	6	64	1.14	128	80
Metribuzin	2.58	1	95	4	66	1.19	126	85
Terbacil	2.13	2	96	4	64	1.21	127	86
Atrazine	3.25	0	52	26	64	1.23	129	77
Untreated	—	—	—	48	58	1.22	130	70
LSD (0.05)	—	2	14	12	5	0.07	NS	6

[1] Ratings were made 8 wks after treatment. Sugarcane (SC) ratings are visual estimates. Johnsongrass (JG) control ratings are based on johnsongrass shoot counts in the treated plots as compared to the untreated plots.

[2] TRS, theoretically recoverable sugar.

Clomazone at all rates caused sugarcane foliage to bleach approximately 7 d after treatment. The bleaching was confined to the treated foliage. Little or no leaf discoloration or reduction in sugarcane shoot heights or numbers was observed 8 WAT indicating that sugarcane continued to grow despite the early injury (Table 3). Johnsongrass competition reduced sugarcane stalk numbers by only 10% when compared to the standard terbacil treatment because johnsongrass developed late in the untreated check (Table 3). All of the herbicide treatments controlled johnsongrass long enough to produce stalk numbers equivalent to the standard terbacil treatment.

Sugarcane stalk weights for the herbicide treatments were similar and differences in TRS among the various treatments were not significant (data not presented). As a result, yields of cane and sugar were directly related. The untreated check had the lowest cane yield and the standard metribuzin and terbacil treatments had the highest cane yields (Table 3). Cane yields following treatment with clomazone at 1.12 and 1.68 kg ha^{-1}, fomesafen at 0.84 and 1.12 kg ha^{-1}, quinclorac, and atrazine were lower than the average for the metribuzin and terbacil treatments. Johnsongrass panicle numbers in plots treated with clomazone at 1.12 and 1.68 kg ha^{-1} were higher than in plots treated with either metribuzin, terbacil, or clomazone at 2.24 kg ha^{-1}. The level of johnsongrass control with fomesafen was equivalent to that observed with the standards. These responses suggest that the reductions in yield associated with clomazone at the lower rates may be attributable to johnsongrass competition and to herbicide injury with fomesafen at the higher rates.

Although not labelled for use within sugarcane, AC 263,222, clomazone, fomesafen, imazapyr, and prodiamine provided levels of johnsongrass control which were equivalent to currently used standards with a minimum of crop injury. Further evaluations of these herbicides on a number of soil types and sugarcane cultivars is warranted.

Postemergence studies

Sugarcane injury in the form of reductions in shoot height was observed 4 WAT with primisulfuron in study E. The greatest amount of injury was observed following the May applications (Table 4). The degree of injury was not affected by asulam in mixture with primisulfuron.

Johnsongrass control 4 wk after the April 14 application of asulam at 2.80 and 3.74 kg ha^{-1} was higher than the 1.68 kg ha^{-1} rate in study E (Table 4). Johnsongrass control following the application of asulam at 3.74 kg ha^{-1} on April 14 and May 4 was similar. Little or no johnsongrass control (20%) was observed following the application of asulam at 1.68 kg ha^{-1} on May 4. Johnsongrass control (stunting) with an April application of primisulfuron at 0.03 kg ha^{-1} was similar to that observed with asulam at 2.80 and 3.74 kg ha^{-1}. Where the application of primisulfuron was delayed until May 4, johnsongrass control was less than the 3.74 kg ha^{-1} rate of asulam. Asulam at 1.68 kg ha^{-1} in mixture with primisulfuron improved the level of johnsongrass control following the May application only.

Johnsongrass panicle numbers were 34%, 43%, and 60% lower than the untreated check following April 14 applications of asulam at 1.68, 2.80, and 3.74 kg ha^{-1}, respectively, and 50% and 68% lower following the May 4 applications of asulam at 1.68 and 3.34 kg ha^{-1}, respectively (Table 4). Johnsongrass control observed 4 WAT in plots treated with primisulfuron in April was no longer evident late in the season because johnsongrass panicle numbers were equivalent to those in the untreated check. Some johnsongrass control was still evident in plots treated with primisulfuron in May because the interval between application and the counting of johnsongrass panicles was shorter than the interval for the April application. Inclusion of asulam in mixture with primisulfuron did not result in a further reduction in panicle numbers when compared to asulam applied alone at 1.68 kg ha^{-1}.

Sugarcane stalk numbers were higher than the untreated check for all treatments except primisulfuron applied on April 14 at 0.02 kg ha^{-1} alone or in mixture with asulam (Table 4). Stalk numbers were highest where asulam was applied at 3.74 kg ha^{-1}. Despite the equivalent levels of johnsongrass control 4 WAT, sugarcane stalk numbers following the April 14 application of primisulfuron at 0.03 kg ha^{-1} were lower than the 3.74 kg ha^{-1} application of asulam. Sugarcane stalk weights were higher than the untreated check only in plots which received an asulam application.

Table 4. Effects of postemergence applications of primisulfuron and asulam on johnsongrass and sugarcane. Study E.

Herbicide(s)	Rate(s)	Applic. date	SC injury[1]	JG control[1]	JG panicles	Stalk no.	Stalk wt.	Cane yield
	(kg ha^{-1})		—— (%)	——	(no. ha^{-1} x 10^3)		(kg)	(Mg ha^{-1})
Primisulfuron	0.02	4/14	6	66	70	38	0.85	37
Primisulfuron	0.03	4/14	7	73	69	43	0.86	39
Primisulfuron + Asulam	0.02 + 1.68	4/14	6	58	65	38	0.88	36
Primisulfuron + Asulam	0.03 + 1.68	4/14	5	68	69	38	0.90	39
Asulam	1.68	4/14	1	51	53	44	0.95	45
Asulam	2.80	4/14	0	78	46	47	0.92	52
Asulam	3.74	4/14	2	77	32	54	0.96	57
Primisulfuron	0.02	5/4	16	50	55	42	0.84	38
Primisulfuron	0.030	5/4	19	62	51	46	0.81	43
Primisulfuron + Asulam	0.02 + 1.68	5/4	8	71	39	47	0.93	47
Primisulfuron + Asulam	0.03 + 1.68	5/4	20	78	42	47	0.92	48
Asulam	1.68	5/4	0	20	40	44	0.89	46
Asulam	3.74	5/4	5	78	25	54	0.98	59
Untreated	—	—			80	32	0.78	29
LSD (0.05)			5	7	16	7	0.08	9

[1] Visual estimates of sugarcane (SC) injury and johnsongrass (JG) control were made 4 wks after each treatment.

Yields of cane were higher than the untreated check except where primisulfuron was applied on April 14 at 0.02 kg ha^{-1} alone or in mixture with asulam at 1.68 kg ha^{-1}. Yields of cane were highest where asulam was applied alone at 3.74 kg ha^{-1}. Treatment differences in TRS were not significant (data not presented). Hence, sugar yields reflected differences in cane yields.

Sugarcane injury with primisulfuron applied on April 7 was slight (<10%) 4 and 8 WAT in study F (Table 5). When the application was delayed until May 4, sugarcane injury in the form of reductions in shoot height and numbers was higher, as was observed in study E. Nicosulfuron at rates of 0.02 and 0.03 kg ha^{-1} resulted in a slight amount of sugarcane injury 4 wk after the April 7 application. At the higher rate of 0.07 kg ha^{-1}, reductions in sugarcane shoot heights and numbers were higher (30%). As with primisulfuron, delaying the postemergence application until May 4 resulted in increased injury. By 8 WAT, sugarcane injury with primisulfuron and nicosulfuron was similar to that observed 4 WAT. Little or no injury was observed 4 and 8 WAT with asulam at 3.74 kg ha^{-1}, regardless of the application date.

Table 5. Effects of postemergence applications of nicosulfuron and primisulfuron on johnsongrass and sugarcane. Study F.

		Applic.	SC injury[2]		JG control[2]		JG	Stalk		Cane
Herbicide(s)	Rate(s)	date[1]	4	8	4	8	panicles	no.	wt.	yield
	(kg ha^{-1})		(%)				(no. ha^{-1} x 10^3)		(kg)	(Mg ha^{-1})
Nicosulfuron	0.02	4/7	2	0	35	18	44	41	0.69	30
Nicosulfuron	0.03	4/7	5	6	61	47	27	49	0.73	38
Nicosulfuron	0.07	4/7	30	28	81	66	28	50	0.64	40
Primisulfuron	0.03	4/7	2	0	31	7	44	33	0.62	18
Primisulfuron	0.07	4/7	2	1	34	17	38	38	0.68	25
Primisulfuron	0.13	4/7	6	3	63	44	36	44	0.69	38
Asulam	3.74	4/7	3	6	83	64	31	48	0.82	48
Nicosulfuron	0.02	5/4	20	20	45	45	30	42	0.64	34
Nicosulfuron	0.03	5/4	19	19	46	46	25	48	0.66	37
Nicosulfuron	0.07	5/4	38	38	64	64	32	43	0.48	30
Primisulfuron	0.03	5/4	7	7	29	29	35	41	0.67	31
Primisulfuron	0.07	5/4	10	10	28	28	33	36	0.64	25
Primisulfuron	0.13	5/4	15	15	36	36	40	45	0.68	35
Asulam	3.74	5/4	1	1	17	17	34	36	0.72	26
Untreated	—	—	—	—	—	—	41	37	0.70	21
LSD (0.05)			5	4	14	15	12	9	0.06	10

[1] Rainfall totalling 1.9 cm fell within 8 h of the May 4 application.

[2] Visual estimates of sugarcane (SC) injury and johnsongrass (JG) control were made 4 and 8 wks after each treatment.

Asulam applied on April 7 provided 83% johnsongrass control 4 WAT. By 8 WAT, regrowth was developing and control was reduced to 64%. Johnsongrass control 4 wk after the May 4 application was significantly lower than the April 7 application. In study E, asulam applied in April and May provided equivalent control. In study F rainfall totalling 1.9 cm fell within 8 h of the May 4 applications. This would indicate that the 8-h rain free period in study F was not of a sufficient duration to insure johnsongrass control with asulam. In previous studies, a period of at least 24 h prior to wash off was required to obtain maximum activity with asulam (10).

The level of johnsongrass control 4 WAT with the April 7 application of primisulfuron at 0.03 kg ha^{-1} in study F was lower than in study E following the April 14 application. Johnsongrass control 4 wk after the May 4 application was also lower than that observed for an equivalent treatment in study E. Rainfall may have had an effect on the performance of primisulfuron applied May 4.

Johnsongrass control with nicosulfuron at 0.07 kg ha^{-1} was equivalent to that observed with asulam 4 and 8 wk after the April 7 application (Table 5). Johnsongrass control following the May 4 application of asulam was lower than that observed with nicosulfuron at all rates indicating that the performance of nicosulfuron was not affected by rainfall to the same degree as asulam.

Johnsongrass panicle numbers in the asulam-treated plots were similar despite the effects of rainfall on the May application. Neither application resulted in panicle numbers lower than the untreated check. Only nicosulfuron at 0.03 and 0.07 kg ha^{-1} applied on April 7 or nicosulfuron at 0.03 kg ha^{-1} applied on May 4 resulted in a reduction of johnsongrass panicles when compared to the untreated check.

Sugarcane stalk numbers increased following treatment with asulam on April 7 to control johnsongrass (Table 5). Similar increases were not observed following the May 7 application of asulam. Of the sulfonylurea herbicides, only nicosulfuron at 0.03 and 0.07 kg ha^{-1} applied on April 7 or nicosulfuron at 0.03 kg ha^{-1} applied on May 4, resulted in stalk number increases similar to those obtained with asulam on April 7.

As in study E, sugarcane stalk weights in study F were higher than the untreated check where asulam was applied in April (Table 5). Stalk weights were equivalent to, and in some cases, less than those obtained in the untreated check where nicosulfuron and primisulfuron were applied.

Effects of the various postemergence treatments on TRS were minimal, as a result sugar yields reflected cane yield responses. Yields of cane were 27.3 Mg ha^{-1} higher than the weedy check following an April 7 application of asulam. Only nicosulfuron at 0.03 and 0.07 kg ha^{-1} and primisulfuron at 0.13 kg ha^{-1} applied on April 7 produced yields of sugar which were equivalent to the April 7 application of asulam (Table 5).

In study G, sugarcane injury 4 WAT with nicosulfuron and primisulfuron at 0.03 kg ha^{-1} was similar (Table 6). By 8 WAT, the level of sugarcane injury with both nicosulfuron and primisulfuron increased with the greatest increase occurring where nicosulfuron was applied. Johnsongrass control 4 WAT with both rates of nicosulfuron was equivalent to that observed with asulam. To get similar levels of control with primisulfuron, 0.07 kg ha^{-1} was required. By 8 WAT, the level of johnsongrass control in plots treated with primisulfuron and with asulam had decreased. This was not the case with nicosulfuron where a slight increase in control was observed. Johnsongrass control with nicosulfuron did not increase between the 4 and 8 wk ratings in study F; however, the regrowth between the 4 and 8 WAT ratings was less where nicosulfuron was applied in study F (Table 5). Johnsongrass panicle numbers were lower than the untreated check in study G only in plots treated with asulam and nicosulfuron (Table 6).

Sugarcane stalk numbers were higher than the untreated check only where nicosulfuron was applied at 0.02 kg ha^{-1} (Table 6). Stalk weights were higher than the untreated check only where asulam was applied. Although stalk weights following applications of either primisulfuron or nicosulfuron were equivalent to the untreated check, all were lower than the stalk weights in plots treated with asulam. A similar response was obtained following the April applications in study F (Table 5). Reductions in stalk size probably reflected the sugarcane injury observed 4 and 8 WAT. Differences in stalk weight were not detected in TRS values (data not presented).

Table 6. Effects of postemergence applications of nicosulfuron and primisulfuron on johnsongrass and sugarcane. Study G.

Herbicide(s)	Rate(s)	SC injury[1]		JG control[1]		JG panicles	Stalk		Cane yield
		4	8	4	8		no.	wt.	
	(kg ha^{-1})	(%)				(no. ha^{-1} x 10^{3})		(kg)	(Mg ha^{-1})
Nicosulfuron	0.02	12	48	74	84	63	37	0.67	33
Nicosulfuron	0.03	13	63	72	87	109	29	0.65	24
Primisulfuron	0.03	12	25	59	28	165	27	0.70	29
Primisulfuron	0.07	19	27	66	30	124	23	0.66	20
Asulam	3.74	2	15	74	46	108	28	0.89	30
Untreated	—	—	—	—	—	206	19	0.72	15
LSD (0.05)		7	11	10	14	88	16	0.10	13

[1] Visual estimates of sugarcane (SC) injury and johnsongrass (JG) control were made 4 and 8 wks after each treatment.

Yields of cane were increased 15 Mg ha^{-1} following the application of asulam at 3.74 kg ha^{-1} (Table 6). Similar increases in yield were observed when nicosulfuron was applied at 0.02 kg ha^{-1} and when primisulfuron was applied at 0.03 kg ha^{-1}. Differences in sugar yields were similar to differences in cane yields because TRS values for the various treatments were similar.

Of the postemergence herbicides evaluated, only nicosulfuron at rates of 0.02 and 0.03 kg ha^{-1} consistently provided levels of johnsongrass control equivalent to asulam. Despite the early-season sugarcane injury, yields of both cane and sugar following treatment with nicosulfuron were similar to asulam. The use of nicosulfuron at lower rates in split applications, as an early application followed by a later application of asulam, or as a spot application to control rhizome johnsongrass should be investigated.

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SUGARCANE RESPONSE TO LIMESTONE AND GYPSUM APPLICATION ON ACIDIC SANDY SOILS[1]

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ABSTRACT

Continued expansion of the Florida sugarcane (interspecific hybrids of *Saccharum* spp.) production area will necessitate increased production on sandy mineral soils of central southern Florida. The objective of our research was to evaluate sugarcane yield response to soil amendments applied for increasing the soil pH of acidic sandy soils. The soil amendments studied permitted evaluation of the individual benefits to sugarcane productivity of neutralizing soil acidity, supplying nutrient Ca, and supplying nutrient Mg. Experiments were conducted on a Myakka sand (Sandy, siliceous, hyperthermic Aeric Haplaquods) and an Immokalee sand (Sandy, siliceous, hyperthermic Arenic Haplaquods). At both locations, the experiment design was a randomized complete block with four replications. Each replication was a factorial of three soil amendments and four application rates. The soil amendments were commercial agricultural calcite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), and gypsum ($CaSO_4 \cdot H_2O$). Calcite and dolomite amendments were both applied at rates of 0, 1.1, 2.2, and 4.4 t ha^{-1}. Gypsum amendment rates (0, 1.9, 3.8, and 7.9 t ha^{-1}) were selected in order to apply an approximately equivalent quantity of amendment Ca as was applied by the calcite amendments. Our research confirmed that dolomite is the preferred liming amendment due to its capacity to supply nutritional Mg. Nutritional Ca supply from these soils appeared adequate. Our research also defined a threshold pH of 5.5, above which liming did not improve sugarcane yield but below which a yield response to liming is expected. Surface soil pH was increased 0.24 pH units per tonne of calcite or dolomite applied. Existing recommendations should be refined to incorporate this new knowledge.

INTRODUCTION

Sugarcane (interspecific hybrids of *Saccharum* spp.) is Florida's most valuable agronomic crop. The Florida sugarcane industry generates 25% of all sugar produced and 19% of all sugar consumed in the United States (USDA, 1992). The Florida sugarcane production area has been expanding steadily since 1960 and, for the 1992-93 harvest season, sugarcane was grown on over 178,000 ha (Coale and Glaz, 1992). For the 1992-93 harvest, 87% of Florida's sugarcane was grown on Histosols in the Everglades Agricultural Area (EAA), while the remaining 13% was grown on adjacent sandy mineral soils (Coale and Glaz, 1992). Nearly all of the Histosols in the EAA potentially available for agricultural production are currently under cultivation. Also, all of Florida's seven raw sugar mills are located in or near the EAA. Hence, continued expansion of the sugarcane industry will be on the sandy mineral soils adjacent to the EAA.

The mineral soils adjacent to the EAA are predominantly classified as Entisols, Mollisols, and Spodosols. Spodosols, primarily of the aquod suborder, are the dominant soils used for sugarcane production (Anderson, 1990). Many of these soils have surface soil pH below that required for optimum sugarcane productivity, and liming for pH adjustment is a common practice. Current liming recommendations were developed by Gascho and Kidder (1975) who recommended applying lime, usually dolomite, at 3.3 t ha^{-1} on sands with pH less than 5.0. Presumably, they developed this recommendation from field observations, growers' experiences, and adaptation of research results from other regions, because substantiating research literature specific to the acidic mineral soils of central southern Florida does not exist.

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Worldwide, various soil amendments have been used in sugarcane production systems for amelioration of the adverse effects of low soil pH. In Hawaii, volcanic soils with pH 5.2 and lower are often amended with 3.3 t ha^{-1} ground coral (Yonemitsu, 1983). On an Ultisol of the humid tropics of Puerto Rico, limestone amendments have been shown to increase sugarcane yields from about 10 t ha^{-1} at pH 3.9 to over 100 t ha^{-1} at pH 4.8 (Abruna-Rodriguez and Vicente-Chandler, 1967). The acidity of clay soils of South Africa has been shown to be decreased with incorporation of limestone or burned brush ash and maximum sugarcane productivity was obtained when soil pH was adjusted to between 5.2 and 5.6 (Meyer, 1970). In each of the preceding examples, the improvement in sugarcane productivity attributed to increased soil pH was a manifestation of increased percent base saturation of the soil exchange phase and reduced Al availability. Sugarcane has been shown to be relatively more tolerant of Al in solution than maize (*Zea mays* L.), soybean (*Glycine max* L.), and navybean (*Phaseolus vulgaris* L.) (Hetherington et al., 1988). The sandy mineral soils available for sugarcane production in Florida typically have low exchangeable Al contents (USDA, 1990), thus, liming these soils is not directed towards ameliorating Al toxicity.

In a series of experiments on acidic silt loam and sandy loam soils in Louisiana, Davidson (1967) concluded that sugarcane and sugar yields were usually increased by liming when the soil pH was below 6.0 and recommended a 6.6 t ha^{-1} application of ground oyster shell. Golden (1972) reconfirmed Davidson's (1967) conclusions and added that liming these acidic soils at the rate of 6.6 t ha^{-1} should result in improved sugarcane yield for four to six years following application.

In Florida, the sandy soils potentially suited for sugarcane production typically have low clay content (1 to 5 %), low organic matter content (1 to 2 %), and a low CEC (1 to 5 cmol$_c$ kg^{-1}) with variable (30 to 80%) base saturation (USDA, 1990). The chemical reaction of these soils with liming amendments will be quite different than the liming reaction observed with highly- weathered, tropical clay soils or with medium-textured soils that have higher clay or organic matter contents. The objective of our research was to evaluate sugarcane yield response to soil amendments applied for increasing the soil pH of acidic sandy Spodosols. The goal of liming is to neutralize soil acidity but liming amendments also provide Ca and sometimes Mg for plant nutrition. The soil amendments studied in our research were selected in order to gain insight into the individual benefits to sugarcane productivity of neutralizing soil acidity, supplying nutrient Ca, and supplying nutrient Mg.

MATERIALS AND METHODS

Experiments were conducted at two locations in Hendry County, Florida. The soil at location 1 was a Myakka sand (Sandy, siliceous, hyperthermic Aeric Haplaquods) which is characterized by clay and organic matter contents less than 2%. The spodic horizon was approximately 50 cm below the soil surface. The initial surface soil (0 to 15 cm) pH was 4.5. The soil at location 2 was an Immokalee sand (Sandy, siliceous, hyperthermic Arenic Haplaquods) which is also characterized by low clay and organic matter contents. The spodic horizon was approximately 90 cm below the soil surface. The initial surface soil (0 to 15 cm) pH was 5.6.

At both locations, the experiment design was a randomized complete block with four replications. Each replication was a factorial of three soil amendments and four application rates. The soil amendments were commercial agricultural calcite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), and gypsum ($CaSO_4 \cdot H_2O$) (Table 1). Amendment Ca and Mg contents were determined by atomic absorption spectroscopy following digestion by HNO_3 and H_2O_2 (USEPA, 1986). Total carbonate content was determined by heating in HCl, filtering, heating the filtrate in NH_4OH, filtering, and igniting the residue (Florida Dept. of Transportation, 1988). The pH of a 1:1 (v:v) amendment:water slurry was determined by glass electrode.

The calcite and dolomite amendments had similar total percent carbonates and, thus, similar acid neutralizing capacities. Both liming materials were applied at rates of 0, 1.1, 2.2, and 4.4 t ha^{-1}. Gypsum was applied at 0, 1.9, 3.8, and 7.6 t ha^{-1}. Gypsum amendment rates were selected in order to apply an approximately equivalent quantity of amendment Ca as was applied by the calcite amendment. All amendments were surface broadcast over the entire plot area and incorporated by roto-tiller to approximately 20 cm depth two days prior to sugarcane planting. Each plot area was 72 m^2 (12 m long, 6 m wide) and included four rows of sugarcane planted on 1.5 m row widths.

Table 1. Selected chemical analyses of amendment materials.

Amendment	Ca	Mg	Carbonates	pH[†]
	---- g	kg^{-1} ----	%	
Calcite	211	4.4	90.2	8.85
Dolomite	148	80.1	91.3	8.38
Gypsum	118	0.1	64.3	5.84

[†] 1:1 amendment:water slurry.

At location 1, the soil amendment treatments were applied 11 Nov. 1986 and 'CP 72-1210' sugarcane was planted on 13 Nov. 1986. At location 2, the soil amendment treatments were applied 2 Dec. 1987 and 'CP 72-1210' sugarcane was planted on 4 Dec. 1987. At both locations, sugarcane was planted using standard commercial planting procedures.

Fertilizer applications were based on pre-plant soil test recommendations (Gascho and Kidder, 1975). At location 1, total N, P, and K fertilizer additions for the plant-cane crop were 191, 50, and 234 kg ha^{-1}, respectively, broadcast applied in four split-applications. The first-ratoon and second-ratoon crops recieved the same fertilizer additions. At location 2, total N, P, and K fertilizer additions were 210, 38, and 232 kg ha^{-1}, respectively, broadcast applied in five split-applications to both the plant-cane and the first-ratoon crops.

Soil samples were collected from 0 to 15, 15 to 30, and 30 to 45 cm depths by combining 12 soil cores from the interrow space adjacent to and between the middle two rows of each four- row plot. The surface soil (0 to 15 cm depth) was sampled frequently throughout the experiment while subsoil samples were collected at mid-season of each crop. Soil samples were analyzed for pH of a 1:2 (v:v) soil:water slurry, water-extractable P (Pw), 0.5 mol L^{-1} acetic acid extractable Ca, and Mg (Sanchez, 1990), and 0.5 mol L^{-1} acetic acid extractable P (Pa).

Twenty top visible dewlap (TVD) leaves were collected from the middle two rows of each plot in June or July of each crop year. The leaf tissue was dried and ground to pass through a 0.85 mm screen. A 0.3 g subsample was digested by the sulfuric acid/hydrogen peroxide method described by Wolf (1982). Nitrogen and P were determined by ammonia-salicylate and phosphomolybdenum colorimetric procedures, respectively (Technicon Industrial Systems, 1977). Potassium, Ca, and Mg assays were conducted using atomic absorption spectrophotometry.

Sugarcane yield data were collected for the plant-cane crops at both locations, the first-ratoon crop at location 2, and the second-ratoon crop at location 1. Prior to crop harvest, millable stalk number per 12 m in the two middle rows of each plot (36 m^2) were counted. At harvest, 15 adjacent stalks were sampled from a random interior section of one of the two middle rows of each plot. The stalks were cut at the soil surface and topped at the upper-most hard node. Each 15-stalk sample was weighed (fresh weight) and each individual stalk length was measured. The harvested stalks were crushed in a three-roller sugarcane mill at 17.25 MPa roller pressure. The expressed juice was analyzed for Brix by laboratory refractometer and for polarization after clarification with $Ca(OH)_2$ and $Al(Cl)_3$ (Clarke and Legendre, 1989).

Statistical analyses were conducted using SAS PROC GLM and PROC NLIN procedures (SAS Institute, 1985).

RESULTS AND DISCUSSION

Soil Response to Amendments

The calcite and dolomite amendments had similar total percent carbonates and similar acid neutralizing capacity (Table 1). The reaction rates of calcite and dolomite amendments were rapid and an apparent pH equilibrium was achieved approximately 2 months after application (location 1 = 53 days after treatment (DAT); location 2 = 66 DAT) (Fig. 1). The magnitude of pH elevation in response to amendment application was similar for both calcite and dolomite amendments. Elevated soil pH resulting from amendment application was maintained throughout experiments (Fig. 1).

Soil samples were collected from the 0 to 15, 15 to 30, and 30 to 45 cm depths at mid-season of the plant-cane crop (location 1 = 103 DAT, location 2 = 220 DAT) to define the soil pH, Ca, and Mg status during the plant-cane grand growth period (Table 2). Increasing rates of both calcite and dolomite amendments resulted in significant increases in soil pH at the 0 to 15 cm depth. Liming did not alter soil pH at the 15 to 30 cm depth at location 1 but did significantly increase soil pH at the 15 to 30 cm depth at location 2. Liming did not alter soil pH at the 30 to 45 cm depth at either location (data not shown).

Calcite and dolomite amendments contained 211 and 148 g Ca kg^{-1}, respectively (Table 1). As a result, acetic acid extractable Ca was increased in the 0 to 15 cm depth by both amendments at both locations (Table 2). Elevated extractable Ca levels were not observed at greater depths except in the 15 to 30 cm depth at location 2.

Dolomite contained 76 g Mg kg^{-1} that was not available from equivalent rates of calcite (Table 1). Increasing rates of dolomite resulted in increasing acetic acid extractable Mg levels in the 0 to 15 and 15 to 30 cm depths at both locations. Magnesium content of the 30 to 45 cm depth was not changed by dolomite application (data not shown).

Soil samples were also collected from the 0 to 15, 15 to 30, and 30 to 45 cm depths at mid-season of the ratoon crops (location 1 = 992 DAT, location 2 = 534 DAT) (Table 2). Increased soil pHs in the 0 to 15 and 15 to 30 cm depths due to calcite and dolomite applications were maintained through the ratoon crops (Table 2 and Fig. 1). Liming did not alter soil pH in the 30 to 45 cm depth.

When location 1 was sampled nearly three years (922 DAT) after liming, a significant increase in extractable Ca in the 0 to 15 and 15 to 30 cm depths persisted (Table 2). Similar observations were made for soil samples collected 534 DAT at location 2 (Table 2).

Elevated soil Mg levels in the 0 to 15 and 15 to 30 cm depths resulting from dolomite application prior to planting were maintained throughout the course of the experiment at both locations (Table 2).

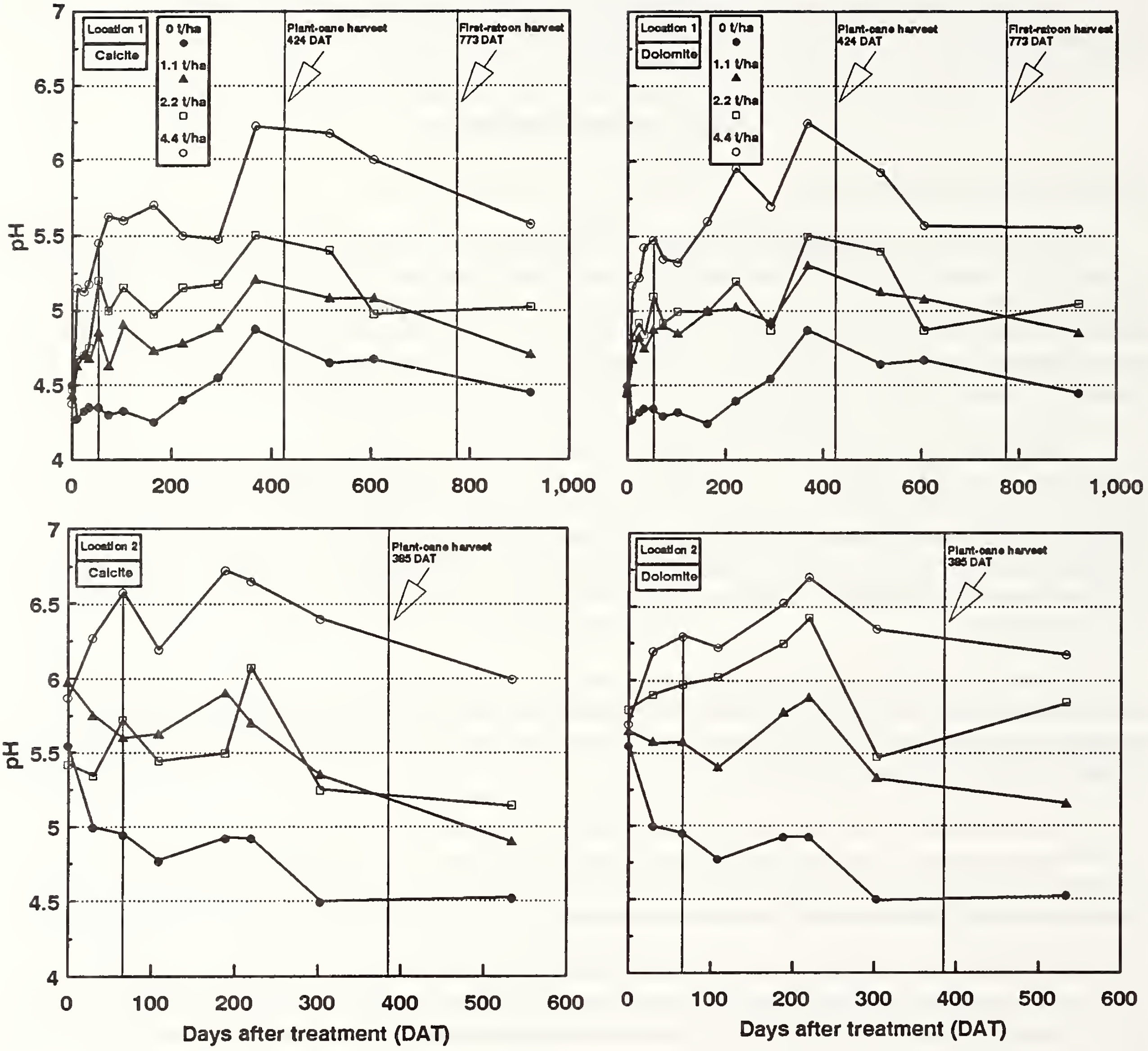

Figure 1. Soil pH (0 to 15 cm depth) as affected by four rates of calcite and dolomite amendments at locations 1 and 2.

Table 2. Soil pH and extractable Ca and Mg in acidic sandy soils amended with calcite, dolomite, or gypsum.

		Calcite			Dolomite			Gypsum[‡]		
Depth	Rate	pH	Ca	Mg	pH	Ca	Mg	pH	Ca	Mg
cm	t/ha		-- μg/ml --			-- μg/ml --			-- μg/ml --	
Location 1, 103 DAT[†]										
0 - 15	0	4.3	165	10.3	4.3	165	10.3	4.3	165	10.3
	1.1	4.9	358	12.4	4.9	181	20.0	4.5	172	9.7
	2.2	5.2	363	10.9	5.0	208	36.2	4.3	220	9.1
	4.4	5.6	428	12.6	5.3	269	58.2	4.4	288	10.0
		**	*	ns	**	**	**	ns	**	ns
15 - 30	0	5.1	141	6.5	5.1	141	6.5	5.1	141	6.5
	1.1	5.3	166	7.6	5.3	143	9.1	5.1	155	8.5
	2.2	5.4	260	8.5	5.1	131	9.1	5.0	175	6.8
	4.4	5.3	151	7.1	5.3	164	12.4	5.1	209	8.5
		ns	ns	ns	ns	ns	**	ns	*	ns
Location 1, 922 DAT										
0 - 15	0	4.5	86	13.5	4.5	86	13.5	4.5	86	13.5
	1.1	4.7	125	19.1	4.9	125	25.3	4.4	94	14.7
	2.2	5.0	167	14.4	5.1	166	37.4	4.4	98	14.7
	4.4	5.6	211	13.8	5.5	247	62.6	4.6	121	14.4
		**	**	ns	**	**	**	ns	**	ns
15 - 30	0	4.2	86	12.9	4.2	86	12.9	4.2	86	12.9
	1.1	4.6	117	15.3	4.6	99	19.1	4.3	93	13.5
	2.2	4.9	167	14.4	4.9	111	24.7	4.3	105	14.4
	4.4	5.6	204	13.2	5.5	167	40.3	4.3	111	11.2
		**	**	ns	**	**	**	ns	**	ns
Location 2, 220 DAT										
0 - 15	0	4.9	64	5.9	4.9	64	5.9	4.9	64	5.9
	1.1	5.7	121	8.8	5.9	90	22.6	4.7	92	6.2
	2.2	6.1	157	7.6	6.4	183	61.8	4.6	145	5.3
	4.4	6.7	236	9.4	6.7	226	92.9	4.3	264	5.9
		**	**	ns	**	**	**	**	**	ns
15 - 30	0	4.9	51	5.9	4.9	51	5.9	4.9	51	5.9
	1.1	5.3	76	7.1	5.4	51	11.5	4.8	69	5.3
	2.2	5.4	79	5.6	5.8	87	22.4	4.7	97	4.7
	4.4	5.9	99	6.2	6.0	67	20.9	4.4	142	4.7
		**	**	ns	**	ns	*	**	**	ns
Location 2, 534 DAT										
0 - 15	0	4.5	64	7.9	4.5	64	7.9	4.5	64	7.9
	1.1	4.9	112	9.1	5.2	111	30.6	4.6	85	9.1
	2.2	5.2	113	7.4	5.9	152	36.2	4.5	83	5.6
	4.4	6.0	222	9.4	6.2	175	77.4	4.5	119	5.9
		**	**	ns	**	**	**	ns	**	ns
15 - 30	0	4.8	50	6.2	4.8	50	6.2	4.8	50	6.2
	1.1	4.9	70	7.6	5.0	53	11.8	4.7	52	6.5
	2.2	4.9	64	6.2	5.3	76	15.9	4.6	56	5.0
	4.4	5.1	78	6.5	5.8	72	21.5	4.5	72	5.9
		ns	ns	ns	**	*	**	*	ns	ns

**, *, ns Linear regression over amendment rates are significant at $P < 0.01$, 0.05, and not significant ($P > 0.05$), respectively.

[†] DAT = days after treatment.

[‡] Gypsum rates = rate x 1.727.

Gypsum amendment rates were selected in order to supply an approximately equivalent quantity of amendment Ca as was available from the calcite amendments without neutralizing soil acidity. Indeed, gypsum application resulted in increased soil Ca similar to the increase resulting from calcite application (Table 2). As expected, gypsum amendments did not alter soil pH when samples were collected at mid-season of each crop at location 1 (Table 2). However, at location 2, mid-season soil pH at the 0 to 15 and 15 to 30 cm depths decreased with increased rates of applied gypsum. This result was unexpected and warrants further study.

Between the time of sugarcane planting and the time the mid-season soil samples were collected for the second ratoon crop at location 1 (922 DAT), the experiment had received a total of approximately 150 kg ha^{-1} of fertilizer P. Water extractable soil P (Pw) determined 922 DAT was not affected by the amendments (Table 3). Acetic acid extractable soil P (Pa) in the 0 to 15 cm depth, however, increased with increasing rates of calcite application (Table 3). Also, in both the 0 to 15 and 15 to 30 cm depths, Pa increased with increasing rates of dolomite application. Neither calcite nor dolomite amendments altered Pa at the 30 to 45 cm depth. Gypsum amendments did not change Pw or Pa at any depth. Limestone and dolomite amendments appeared to have created a soil resevoir for long-term accumulation of fertilizer P with limited water solubility. This P sorption may be detrimental to sugarcane productivity if P nutrition is limiting crop growth or it may be beneficial if sorbed P slowly became plant available in what is typically a well leached root zone. Also, if P fertilizer application exceeded crop P utilization, P sorption by soil amendments may result in lower P loading in field drainage water which may be beneficial to adjacent wetland ecosystems (Izuno et al., 1991). The impact of soil amendments on soil P dynamics in these soils warrants further study.

Table 3. Acetic acid extractable P (Pa) and water extractable P (Pw) in an acidic sandy soil (Location 1) 922 d after amendment with calcite, dolomite, or gypsum.

	Calcite			Dolomite			Gypsum		
Depth	Rate	Pa	Pw	Rate	Pa	Pw	Rate	Pa	Pw
cm	t/ha	--μg/ml--		t/ha	--μg/ml--		t/ha	--μg/ml--	
0 - 15	0	1.4	1.1	0	1.4	1.1	0	1.4	1.1
	1.1	2.4	1.6	1.1	2.4	1.7	1.9	1.0	0.9
	2.2	3.5	1.5	2.2	2.1	1.2	3.8	1.7	1.5
	4.4	3.4	1.3	4.4	3.7	1.4	7.6	1.6	1.4
		*	ns		**	ns		ns	ns
15 - 30	0	1.4	1.2	0	1.4	1.2	0	1.4	1.1
	1.1	1.7	1.3	1.1	2.2	1.4	1.9	1.2	0.9
	2.2	3.1	1.4	2.2	2.5	1.5	3.8	1.8	1.5
	4.4	2.5	1.2	4.4	3.5	1.4	7.6	1.6	1.2
		ns	ns		**	ns		ns	ns

**, *, ns Linear regression over amendment rates are significant at $P < 0.01$, 0.05, and not significant ($P > 0.05$), respectively.

Crop Response to Amendments

Sugar cane yield and yield components data were not influenced by location x year (plant cane or ratoon cane) interactions (Table 4) and, therefore, all yield data are presented by year combined across locations. The plant-cane crops did not exhibit a significant increase in sugarcane yield with increased rate of calcite or dolomite application (Fig. 2). However, the sugarcane yield of subsequent ratoon crops significantly increased ($P \leq 0.10$) with application of calcite and dolomite prior to planting (Fig. 2). The sugarcane yield response for both amendments was linear through the highest amendment rate. The rate response was greater for dolomite than for calcite which suggested an additional benefit of supplying nutritional Mg in conjunction with neutralizing soil acidity.

Sugarcane yield was not affected by gypsum amendments (data not shown). Apparently, the supply of nutrient Ca was not a growth limiting factor for sugarcane production on the these acidic sandy soils.

Inspection of plant cane yield components revealed that there were no significant differences ($P > 0.10$) in stalk length, stalk weight, millable stalk number, or sugar content among calcite or dolomite amendments (Table 5). However, for the subsequent ratoon crops, stalk length and stalk weight significantly increased ($P < 0.05$) with liming. Millable stalk number was significantly increased ($P < 0.10$) by application of dolomite but not by calcite. The similarity of the means for each amendment rate suggests that the differential response in stalk number between the calcite and dolomite amendments may not be meaningful (Table 5). Sugar content was not affected by any of the treatments. Hence, ultimate sugar yield was solely dependent on sugarcane yield and not sugar concentration.

Top visible dewlap (TVD) leaf samples were collected at the beginning of the grand growth period (June or July) of each harvested crop. There were no significant differences ($P > 0.10$) in TVD N, P, K, Ca, or Mg concentrations among the amendment treatments (data not shown). Apparently, although application of supplemental Mg through dolomite amendments was beneficial to sugarcane yield, the Mg deficit was not expressed in TVD leaf Mg concentrations.

For each of the four harvested crops, an "equilibrium pH" for the 0 to 15 cm depth was identified and was used to characterize the average surface soil pH during the majority of crop development. Equilibrium pH is the pH measured approximately 2 months after amendment application for plant-cane crops (location 1 = 53 DAT; location 2 = 66 DAT) and mid-season for ratoon crops (location 1 = 922 DAT; location 2 = 534 DAT). A significant ($P < 0.05$) quadratic model best described the relationship between equilibrium pH for calcite and dolomite amended plots and relative sugarcane yield (Fig. 3). A linear response and plateau model ($R = 0.58$), a quadratic response and plateau model ($R = 0.61$), and a Mitscherlich model ($R = 0.62$) were also evaluated but did not fit the data as well as the quadratic model ($R = 0.64$). Evaluation of the model disclosed that maximum relative sugarcane yield corresponded to pH = 6.0. This pH threshold is the same as that defined by Davidson (1967) and recomfirmed by Golden (1972) for loam soils in Louisiana. Inspection of the treatment means revealed a slightly lower practical threshold of approximately pH = 5.5, above which liming did not improve sugarcane yield.

Since the initial soil pH at location 1 was well below the newly established threshold, the soil pH response to amendment rate at location 1 was used to complete the calibration of amendment rates. The relationship between calcite or dolomite amendment rate and equilbrium pH was defined by a significant ($P < 0.05$) linear model: $\text{pH} = 4.49 + 0.24 * \text{amendment rate (t ha}^{-1})$ ($r^2 = 0.81$). For each tonne of calcite or dolomite applied, equilibrium pH increased 0.24 units.

Table 4. Summary analysis of variance mean squares (MS) and F-statistics for sugarcane and sugar yield.

		Sugarcane yield		Sugar content		Sugar yield	
Source	df	MS	F	MS	F	MSx10^{-4}	F
Location (L)	1	63799	26.94**	5209	17.62**	114.1	20.28**
Year (Y)	1	19288	8.14*	13795	46.65**	72.5	12.87**
L * Y	1	532	0.22	238	0.80	2.5	0.44
Blocks/L * Y	12	2368	----	296	----	5.6	----
Amendment (A)	2	2465	7.35**	226	3.15*	6.6	8.61**
A * L	2	189	0.56	7	0.10	0.5	0.64
A * Y	2	223	0.66	17	0.24	0.5	0.59
A * L * Y	2	1669	4.98**	61	0.86	2.9	3.74*
Pooled error	168	335	----	72	----	0.8	----

**, * F-statistic is significant at $P < 0.01$ and 0.05, respectively.

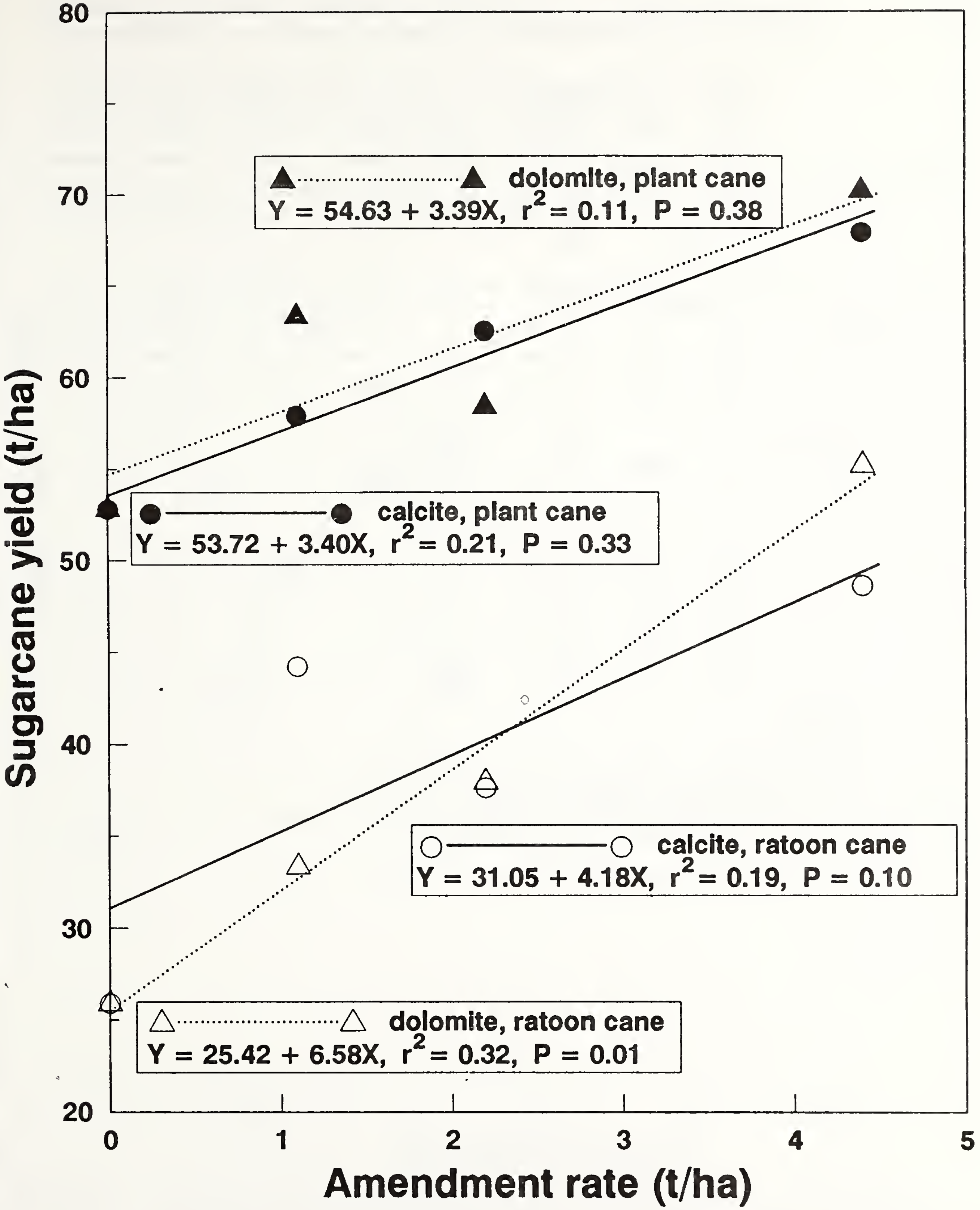

Figure 2. Plant cane and ratoon sugarcane yield response to calcite and dolomite amendments. Sugarcane yields are the mean of two locations (n = 8).

Table 5. Plant cane and ratoon cane yield component responses to rates of soil amendments applied prior to sugarcane planting. Data shown are means over two locations (n = 8).

		Plant cane				Ratoon cane			
Amendment	Rate	Stalk length	Stalk weight	Millable stalks	Sugar content	Stalk length	Stalk weight	Millable stalks	Sugar content
	t ha^{-1}	m	kg	no. ha^{-1}	kg t^{-1}	m	kg	no. ha^{-1}	kg t^{-1}
Calcite	0	1.58	0.83	56 610	141	1.14	0.51	46 654	120
	1.1	1.72	0.93	57 608	139	1.54	0.71	59 626	127
	2.2	1.74	0.94	63 696	141	1.41	0.62	57 350	123
	4.4	1.78	0.92	70 592	138	1.58	0.72	65 087	121
	Signif.								
	linear	ns	ns	ns	ns	*	*	ns	ns
	quad.	ns	ns	ns	ns	ns	ns	ns	ns
Dolomite	0	1.58	0.83	56 610	141	1.14	0.51	46 654	120
	1.1	1.67	0.94	63 764	140	1.42	0.63	50 735	123
	2.2	1.75	0.92	61 824	139	1.39	0.63	55 915	124
	4.4	1.86	0.97	67 307	137	1.73	0.85	65 782	126
	Signif.								
	linear	ns	ns	ns	ns	**	**	†	ns
	quad.	ns	ns	ns	ns	ns	ns	ns	ns

†, *, ** Regression significant at $P < 0.10$, 0.05, and 0.01, respectively. ns = not significant ($P > 0.10$).

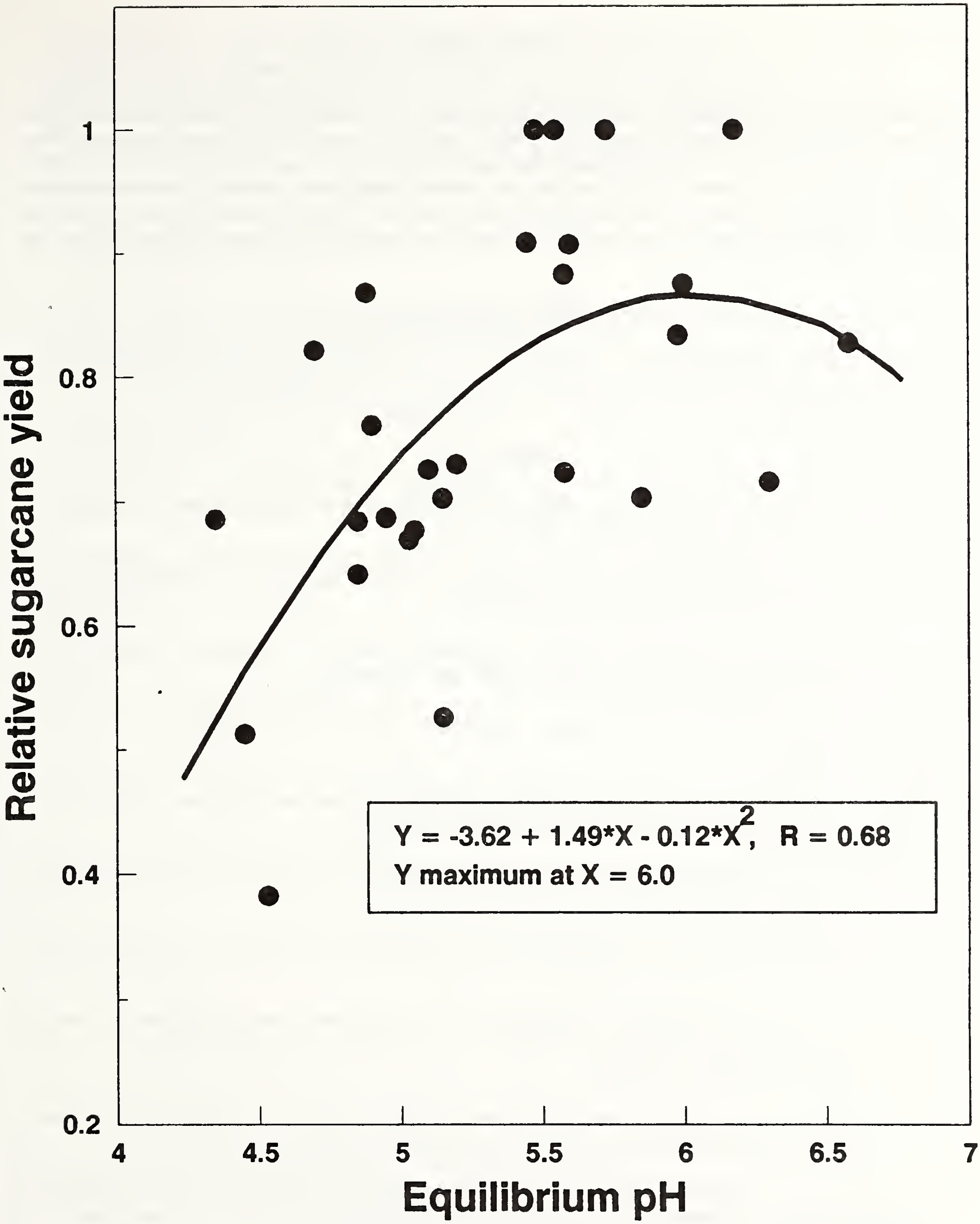

Figure 3. Sugarcane relative yield response to surface soil (0 to 15 cm depth) equilibrium pH. Equilibrium pH is the pH measured approximately 2 months after treatment for plant-cane crops (location 1 = 53 DAT; location 2 = 66) and mid-season for ratoon crops (location 1 = 922 DAT; location 2 = 534 DAT).

CONCLUSIONS

Existing recommendations for growing sugarcane on acidic sandy soils include application of 3.3 t dolomite ha^{-1} on soils with pH less than 5.0 (Gascho and Kidder, 1975). Our research confirms that dolomite is the preferred liming amendment due to its capacity to supply nutritional Mg. Nutritional Ca supply from these soils appeared to be adequate. Our research also defined a practical threshold of pH = 5.5, above which liming did not improve sugarcane yield but below which a yield response to liming is expected. Surface soil pH was increased 0.24 pH units per tonne of limestone or dolomite applied. Existing recommendations should be refined to incorporate this new knowledge.

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SUGARCANE CULTIVAR RESPONSE TO DOLOMITE AMENDMENT OF AN ACIDIC SANDY SOIL[1]

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ABSTRACT

Nearly all of the Florida Histosols potentially available for sugarcane production are currently under cultivation and continued expansion of the sugarcane industry will necessitate increased production on sandy mineral soils. The objective of the present research was to determine the yield responses of several commercial sugarcane cultivars to dolomite amendment of an acidic sandy mineral soil. A field experiment was conducted in Hendry County, Florida, on an Immokalee sand (Sandy, siliceous, hyperthermic Arenic Haplaquods). A randomized split-plot experiment design with four replications was used to evaluate sugarcane yield response to two rates of agricultural dolomite ($CaMgCO_3$) amendment (main plot) and ten cultivars (split plot). The surface soil pH and soil-test Mg levels of the dolomite amended and unamended main plots were significantly different throughout the course of this experiment. For both plant-cane and first-ratoon harvests, cane yield and sugar yield of dolomite amended plots were greater than yields from unamended plots. There were no amendment x cultivar interactions for yield or yield components. For the plant-cane crop, there were significant differences in yield among cultivars, but for the first-ratoon crop, yields were not influenced by cultivar. Liming had relatively little impact on plant-cane yields whereas large first-ratoon yield increases resulted from liming. Overall, liming acidic sandy soils with dolomite improved sugarcane productivity regardless of the cultivar being grown. Most of the yield benefit resulting from pre-plant incorporation of dolomite was evident in the first-ratoon crop. Maintaining productivity over a multi-year crop cycle is the primary benefit derived from liming acidic sandy soils.

INTRODUCTION

The Florida sugarcane (interspecific hybrids of Saccharum spp.) production area has been expanding steadily since 1960 and sugarcane was produced on over 178,000 ha for the 1992-93 harvest season (Coale and Glaz, 1992). For the 1992-93 harvest, 87% of Florida's sugarcane was grown on Histosols in the Everglades Agricultural Area (EAA), while the remaining 13% was grown on adjacent sandy mineral soils (Coale and Glaz, 1992). Nearly all of the Histosols in the EAA potentially available for agricultural production are currently under cultivation. Hence, continued expansion of the sugarcane industry will necessitate increased production on the sandy mineral soils adjacent to the EAA.

Spodosols, primarily of the aquod suborder, are the dominant mineral soils used for sugarcane production in Florida (Anderson, 1990). Many of these sandy Spodosols have surface soil pH below that required for optimum sugarcane productivity and liming for pH adjustment is a common practice. Coale and Schueneman (1993) identified a threshold of pH = 5.5, below which a sugarcane yield response to increasing the pH of an acidic Florida Spodosols was expected. They determined that in order to increase the surface soil pH 1.0 unit, approximately 4 t ha^{-1} of commercial dolomite should be incorporated prior to planting.

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The cooperative sugarcane cultivar development program (USDA-ARS, Univ. of Florida, and Florida Sugar Cane League, Inc.) has recognized the existence of dramatic cultivar responses to soil type and currently conducts final replicated selection experiments on sandy soils as well as organic soils (Glaz et al., 1992). Cultivar differences in response to varying fertility status of a single soil have been demonstrated in numerous sugarcane growing regions. In South Africa, sugarcane and sugar yield response to N fertilization of loam soil has been shown to be cultivar dependent (Inman-Bamber, 1984). Similar conclusions have been drawn from research conducted in India (Singh, 1974). Sugarcane response to soil water status (Escolar and Allison, 1976), herbicide injury (Millhollon and Fanguy, 1989), and growth regulator activity (Dusky et al., 1986) have also been shown to be cultivar specific.

Sub-optimal soil pH has been demonstrated to be a yield limiting constraint to sugarcane production on acidic sandy mineral soils in Florida (Coale and Schueneman, 1993). Fortunately, this detrimental soil condition is easily remedied by liming with dolomite. However, not all of the low pH soils that would benefit from liming are limed. Therefore, it would be useful to know the relative productivity of sugarcane cultivars grown on unamended acidic sandy soils and dolomite amended soils. The objective of this research was to determine the yield responses of several commercial sugarcane cultivars to dolomite amendment of an acidic sandy mineral soil.

MATERIALS AND METHODS

A field experiment was conducted on an Immokalee sand (Sandy, siliceous, hyperthermic Arenic Haplaquods) in Hendry County, Florida. A randomized split-plot experiment design with four replications was used to evaluate sugarcane yield response to two rates of agricultural dolomite ($CaMgCO_3$) amendment (main plot) and ten cultivars (split plot). The ten cultivars were: CP72-1210, CP70-1133, CP74-2005, CP72-2086, CP78-2114, CP78-1247, CP75-1553, CP73-1547, CP80-1827, and CP80-1557. Dolomite amendment rates of 0 and 4.4 t ha^{-1} were incorporated in the main-plots (33 m wide, 9 m long) by rototiller to approximately 0.2 m depth two days prior to sugarcane planting. Sugarcane was planted on 1.5 m row spacing in adjacent two-row subplots (3 m wide, 9 m long) on 11 Dec. 1987. The first and last subplots within each main plot were bordered with one additional row of sugarcane. Fertilizer applications were based on pre-plant soil test recommendations and total N, P, and K fertilizer additions were 210, 38, and 232 kg ha^{-1}, respectively, broadcast applied in five split applications to both the plant-cane and first-ratoon crops.

Soil samples (0 - 20 cm depth) were collected from each subplot prior to dolomite application (0 days after treatment (DAT)) and 143, 304, 535, and 831 DAT. At each sampling date, soil was analyzed for pH of a 1:2 (v:v) soil:water slurry, and 0.5 mol L^{-1} acetic acid extractable Ca and Mg (Sanchez, 1990).

Millable stalk population estimates were determined by counting all hard stalks greater than 1.2 m tall in two 9 m sections of row (27 m^2). Plant-cane stalk counts were conducted on 20 Oct. 1988, and first-ratoon stalk counts were conducted on 3 Nov. 1989.

The plant-cane crop was harvested on 21 Dec. 1988, and the first-ratoon crop was harvested on 19 Dec. 1989. At harvest, 15 adjacent stalks were collected from a random interior portion of one row in each subplot. The stalks were cut at the soil surface and topped at the upper-most hard node. Each 15-stalk sample was weighed. The harvested stalks were crushed in a three-roller sugarcane mill and the expressed juice was analyzed for brix by laboratory refractometer and polarization after clarification with $Ca(OH)_2$ and $Al(Cl)_3$ (Clarke and Legendre, 1989). Theoretical recoverable sugar (TRS) was determined according to Arceneaux (1935).

Statistical analyses were conducted using SAS PROC GLM procedures (SAS Institute, 1985).

RESULTS AND DISCUSSION

All ten sugarcane cultivars evaluated in this study have been grown commercially on the organic soils of the EAA. Included in this list are three cultivars (CP72-1210, CP70-1133, and CP73-1547) that, in addition to being popular for production on organic soils, are preferred for commercial sugarcane production on the sandy soils of southern central Florida (Coale and Glaz, 1992).

The surface soil pH of the dolomite amended and unamended main plots was significantly different throughout the course of this experiment (Fig. 1, Table 1). The control plot pH remained below 5.5 and the dolomite amended plot pH was maintained above the critical threshold of pH = 5.5 (Coale and Schueneman, 1993).

Table 1. Summary analysis of variance for effect of dolomite amendment on soil-test parameters determined at five time intervals.

DAT[†]	Soil-test parameter	df	MSE	F	P > F
0	pH	3	0.0067	3.00	0.1817
	Ca	3	1110.3	0.26	0.6456
	Mg	3	51.000	0.98	0.3951
143	pH	3	0.0013	2601	0.0001
	Ca	3	1452.0	167	0.0010
	Mg	3	77.458	622	0.0001
304	pH	3	0.0333	118	0.0017
	Ca	3	13322	9.65	0.0530
	Mg	3	2497.7	8.83	0.0590
535	pH	3	0.0083	577	0.0002
	Ca	3	1640.3	69.7	0.0036
	Mg	3	270.83	118	0.0017
831	pH	3	0.0750	48.6	0.0061
	Ca	3	4510.8	35.6	0.0094
	Mg	3	1643.7	17.2	0.0254

[†] DAT = Days after treatment. 0 DAT = prior to dolomite application.

The dolomite amendment added an additional 350 kg Mg ha^{-1} (80.1 g Mg kg^{-1} dolomite) to the root zone. Soil-test Mg levels were significantly different between the control and dolomite amended main plots throughout the experiment (Fig. 2, Table 1). Soil-test Mg in the amended plots was above the critical level of 30 mg L^{-1} (Sanchez, 1990), while control plot soil-test Mg levels remained low. Recent evaluation of alternative liming amendments revealed that sugarcane yield response to dolomite application to acidic sandy soils was a combined response to: 1) correction of sub-optimum soil pH, and 2) supplemental nutritional Mg supply (Coale and Schueneman, 1993). Whether the yield responses discussed in this current study were due to pH correction alone, supplemental nutritional Mg supply alone, or a combination of the two, can not be determined. Regardless, dolomite is the recommended liming amendment for sugarcane production on acidic sandy soils in Florida (Coale and Schueneman, 1993) and evaluation of cultivar response to commercial liming practices was the current objective.

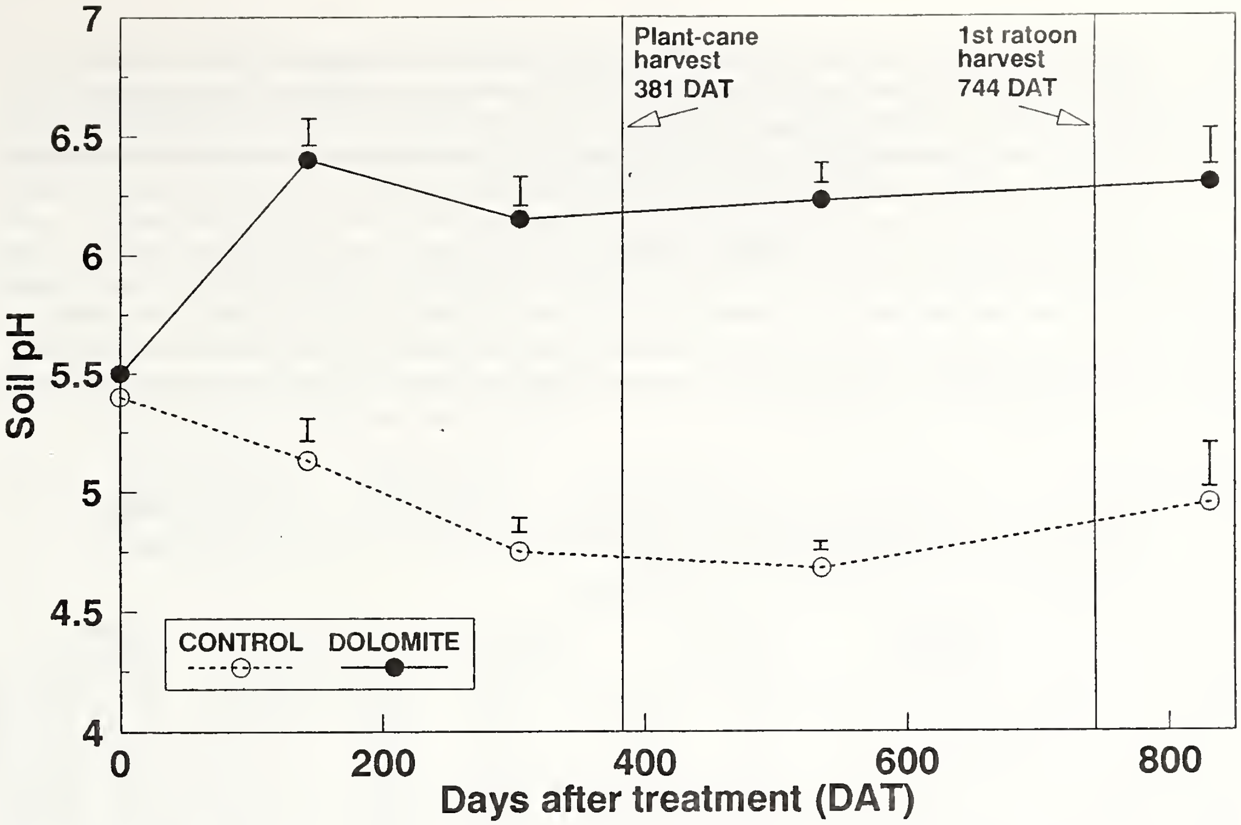

Figure 1. Soil pH (0 - 20 cm depth) of dolomite amended (4.4 tonne ha^{-1}) and unamended main plots. Vertical bars are standard error of the mean (n = 4).

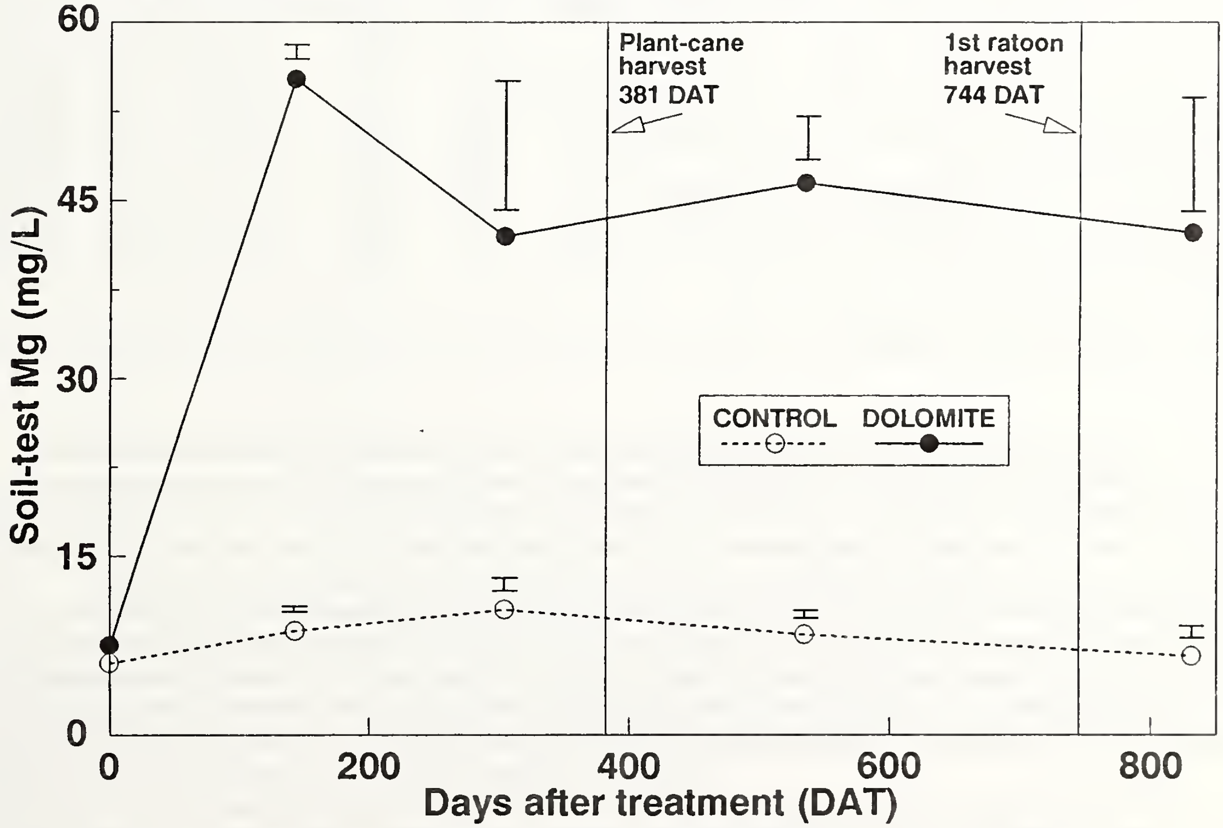

Figure 2. Soil-test Mg (0 - 20 cm depth) of dolomite amended (4.4 tonne ha^{-1}) and unamended main plots. Vertical bars are standard error of the mean (n = 4).

Soil-test Ca (data not shown) was also significantly different between the limed and unlimed plots (Table 1). Coale and Schueneman (1993) determined that the native supply of nutrient Ca was not a growth limiting factor for sugarcane production on these acidic sandy soils and, therefore, the supplemental Ca supply (650 kg Ca ha^{-1}) resulting from dolomite application in the current study should not have affected sugarcane productivity.

The main-plot effect of dolomite amendment on sugarcane and sugar yields was similar for plant-cane and first-ratoon harvests. When averaged across cultivars, cane yield and sugar yield of amended and unamended plots were significantly different (Table 2). Theoretically recoverable sugar (TRS) was not significantly different between main-plot treatments for either crop. Millable stalk number and individual stalk weights were significantly altered by dolomite amendment for the first-ratoon crop but not for plant cane.

Table 2. Summary analysis of variance for the effects of dolomite amendment (main plot) and cultivars (split plot) on sugarcane yield, sugar yield, and yield components for plant cane and first-ratoon crop harvests.

		Millable stalks		Stalk weight		Cane yield		TRS[†]		Sugar yield	
Source	df	MS[‡]	P > F	MS	P > F	MS	P > F	MS	P > F	MS	P > F
		(x10^8)									
PLANT CANE											
Amendment (A)	1	5.5	0.1825	0.037	0.2945	849.1	0.0416	5.2	0.7181	19.05	0.0097
Error a	3	1.9	------	0.023	------	72.2	------	33.2	------	0.55	------
Cultivar (C)	9	6.9	0.0001	0.182	0.0021	545.9	0.0117	448.2	0.0001	10.07	0.0168
A x C	9	0.8	0.8316	0.024	0.9016	281.9	0.2165	15.3	0.9364	5.97	0.1692
Error b	54	1.4	------	0.053	------	203.1	------	39.6	------	3.96	------
1st RATOON											
Amendment (A)	1	157	0.0018	4.146	0.0021	26682.0	0.0045	44.8	0.5450	55.20	0.0050
Error a	3	1.4	------	0.041	------	448.2	------	96.7	------	7.16	------
Cultivar (C)	9	6.0	0.0136	0.161	0.0001	413.6	0.2048	150.3	0.2182	6.32	0.2126
A x C	9	1.6	0.7009	0.045	0.2428	220.8	0.6571	184.8	0.1320	3.26	0.6859
Error b	54	2.3	------	0.034	------	292.2	------	113.6	------	4.52	------

[†] TRS = Theoretically recoverable sugar.
[‡] MS = ANOVA mean square.

There were significant differences among cultivars for all yield and yield component data collected for the plant-cane crop (Table 2). However, there were no significant amendment x cultivar interactions (Table 2). Apparently, there was a wide spectrum of genetic variability in yield potential within this group of ten cultivars, but, for plant cane, each cultivar demonstrated similar yield responses to dolomite amendment. Only two cultivars, CP75-1553 and CP73-1547, exhibited marginally significant ($P < 0.10$) increases in plant-cane sugarcane and sugar yields due to dolomite amendment (Table 3). It is interesting to note that CP73-1547 is one of the three most widely grown cultivars on sandy soils in Florida (Coale and Glaz, 1992). Overall, liming acidic sandy Spodosols had relatively little impact on the plant-cane yield. This same conclusion was presented in earlier studies (Coale and Schueneman, 1993).

For the first-ratoon crop, sugarcane and sugar yields were not influenced by cultivar (Table 2). Measured millable stalk population and stalk weight were cultivar dependent, but there was no significant differences in ultimate yields among cultivars (Table 2). Also, there were no significant amendment x cultivar interactions for first-ratoon yield or yield components (Table 2). For the first-ratoon harvest, cultivar yields, averaged over amendment treatments, were not significantly different and the yield response of each culitvar to dolomite amendment was similar. Dolomite amendment resulted in increased first-ratoon sugarcane and sugar yields for nine of the ten cultivars evaluated (Table 3). Only CP80-1557 did not show a significant yield increase due to liming. Again, these observations concur with previous findings that the yield benefit derived from liming acidic Spodosols is greater for ratoon crops than plant-cane crops (Coale and Schueneman, 1993).

Table 3. Sugarcane yield, sugar yield, and yield components of ten commercial sugarcane cultivars as affected by dolomite amendment.

Cultivar	Millable stalks Control	Millable stalks Amended	Stalk weight Control	Stalk weight Amended	Cane yield Control	Cane yield Amended	TRS[†] Control	TRS[†] Amended	Sugar yield Control	Sugar yield Amended
	thousand ha^{-1}		kg stalk^{-1}		Mg ha^{-1}		kg Mg^{-1}		Mg ha^{-1}	
					PLANT CANE					
CP72-1210	62.6	61.7	0.81	0.63	50.4	38.8	152	149	7.7	5.8
CP70-1133	48.4	61.8	0.84	0.89	41.2	55.4	156	156	6.4	8.6
CP74-2005	46.8	51.5	0.70	0.78	33.5	40.5	159	164	5.4	6.7
CP72-2086	56.3	63.1	0.82	0.95	45.7	59.6	158	157	7.2	9.4
CP78-2114	55.7	56.8	0.84	0.81	46.8	46.7	149	149	7.0	7.0
CP78-1247	51.1	47.4	0.97	0.98	49.6	46.8	144	148	7.1	6.9
CP75-1553	52.9	63.0	0.67	0.74	35.9 +	46.4	137	139	4.9 +	6.5
CP73-1547	45.1 *	59.1	1.04	1.29	46.9 +	76.4	153	150	7.2 +	11.5
CP80-1827	40.1 +	48.6	1.05	1.08	42.7	52.5	154	152	6.6	8.0
CP80-1557	30.9	29.7	0.84	0.86	34.3	29.0	136	141	6.2	5.4
					1st RATOON					
CP72-1210	38.5 *	72.2	0.40 **	0.79	16.2 *	58.0	126	119	2.0 *	6.6
CP70-1133	37.0 +	70.0	0.40 *	0.86	15.4 *	60.2	141	120	2.1 **	7.1
CP74-2005	28.1 +	50.1	0.39	0.58	12.0	28.9	128	136	1.5 +	4.0
CP72-2086	21.7 *	55.7	0.32 *	0.80	7.4 **	43.1	132	132	1.0 **	5.7
CP78-2114	45.5 *	65.8	0.48	0.79	21.8 +	51.2	123	130	2.7 +	6.6
CP78-1247	23.9 +	43.1	0.44 *	0.89	10.7 *	39.5	119	133	1.3 *	5.2
CP75-1553	16.2 **	60.5	0.20 **	0.73	4.4 *	46.0	117	126	0.7 +	5.8
CP73-1547	34.4 *	49.3	0.69 *	1.11	24.7 **	54.7	124	129	3.2 **	7.1
CP80-1827	23.9 *	56.8	0.49 +	1.10	12.3 +	66.1	133	137	1.6 +	9.1
CP80-1557	20.2	45.7	0.44 *	1.17	12.2	54.6	124	123	2.0	6.6

[†] TRS = Theoretically recoverable sugar (kg sugar Mg^{-1} cane).

**, *, + Treatment means within each cultivar are significantly different at $P < 0.01$, 0.05, and 0.10, respectively.

Upon evaluating the sugarcane yield of dolomite amended plots relative to unamended control plots, the impact of liming on ratoon-crop yield is readily apparent (Fig. 3). Small relative yield increases for plant cane due to liming were cultivar specific. However, large relative yield increases for ratoon cane resulting from liming were not cultivar specific (Table 2).

Overall, liming acidic sandy soils with dolomite improved sugarcane productivity regardless of the cultivar being grown. Most of the yield benefit resulting from pre-plant incorporation of dolomite was evident in the first-ratoon crop. Sugar yields of the dolomite amended first-ratoon crop averaged 84% of plant cane sugar yield. Sugar yields of the unamended first-ratoon crop averaged 27% of the plant cane sugar yield. Maintaining productivity over a multi-year crop cycle is the primary benefit derived from liming acidic sandy soils.

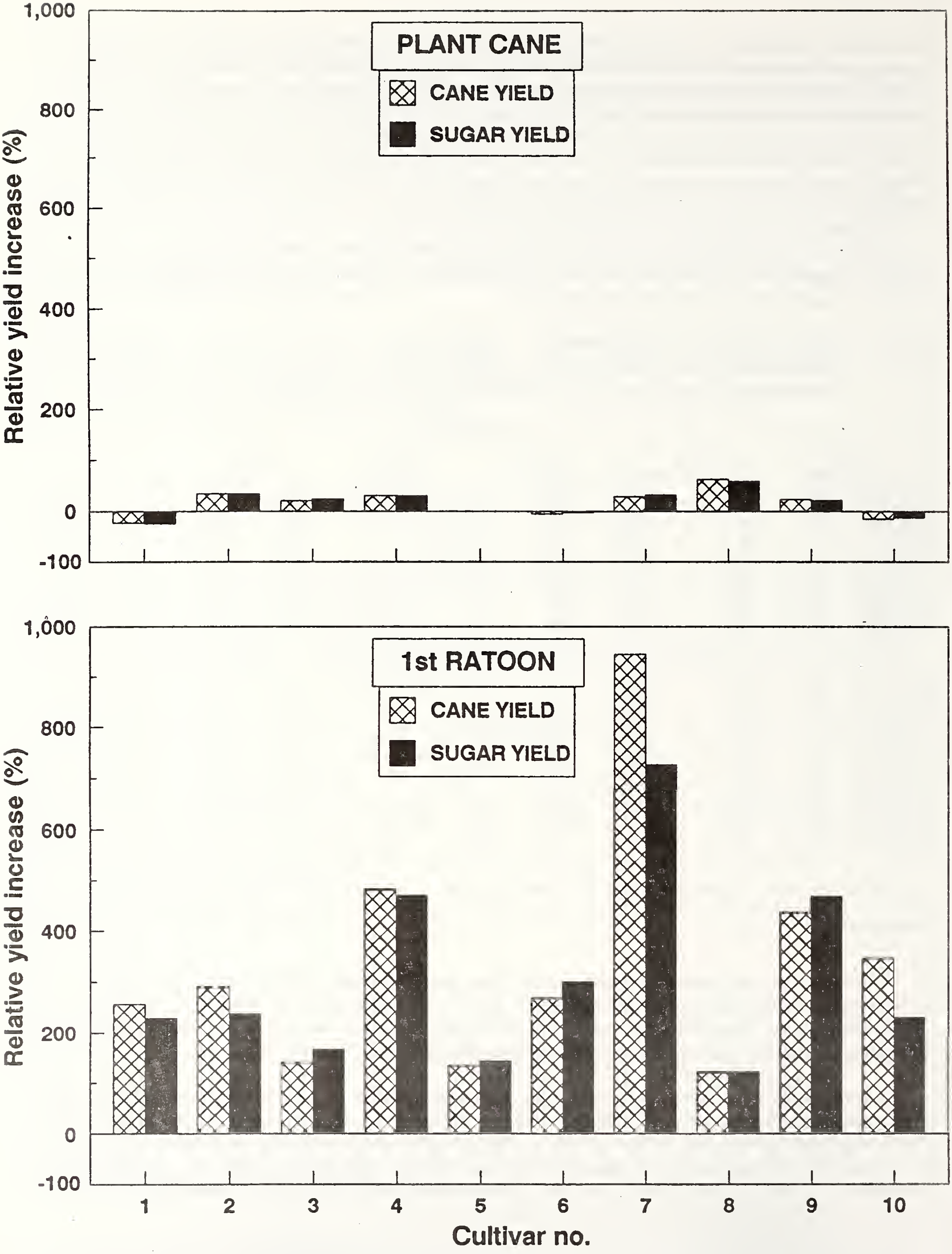

Figure 3. Relative increase in sugarcane and sugar yield of ten cultivars grown on a dolomite amended acidic sandy soil as compared to unamended soil.

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AGRICULTURAL ABSTRACTS

Sugarcane, Phosphorus, Water, The Everglades, and a Pinch of Science

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Recently, sugarcane production in the Everglades Agricultural Area (EAA) of southern Florida has come under scrutiny because of concerns regarding the proposed impact of P-enriched drainage water on the ecology of adjoining wetlands. The objective of this presentation is to summarize research conducted to define P accumulation and harvest removal by a sugarcane crop, the P concentration and off-fields loads in drainage water from sugarcane and fallow fields, and the impact of altering field drainage rate on drainage water P. Sugarcane dry weight and P accumulation were characterized by logistic growth models. At harvest, 71% of total dry matter and 63% of total accumulated P were removed from the field as millable cane. Phosphorus removal by crop harvest was equivalent to 179% of added fertilizer P. Drainage water volume, total P (TP), and total dissolved P (TDP) concentrations were monitored during 12 drainage events over two crop seasons. No significant differences were found in TP or TDP concentrations in drainage water from sugarcane and fallow plots during any of the drainage events monitored. Changes in field drainage rate altered drainage water TP and TDP concentrations but not consistently during all drainage events monitored. Drainage water TP and TDP concentrations were not constant during the course of a given drainage event. Although the impact of sugarcane production on P in field drainage water appears to be minimal, drainage water P concentrations and off-field loads can be manipulated by drainage water management.

Distribution and Abundance of Imported Fire Ants (Hymenoptera: Formicidae) in Florida sugarcane fields

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Twenty-eight sugarcane fields in Florida were sampled for ants using baits or pitfall traps. Using baits, the imported fire ant, *Solenopsis invicta* Buren, was clearly the dominant ant species being found in the highest percentage of all fields, the highest percentage of all bait cards, the greatest total number caught, and the highest relative abundance. Using pitfall traps, *S. invicta* was again the dominant ant species being found in the highest percentage of all fields, the highest percentage of all pitfall traps, the greatest total number caught, and the highest relative abundance. *S. invicta* was first found in Florida sugarcane in 1970. Our data show that since 1970, *S. invicta* has become the dominant ant species in Florida sugarcane resulting in a large reduction in the relative abundance of other ant species.

Influence of Short-term Flooding on Initial Stand Establishment of Sugarcane

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In the Everglades Agricultural Area of Florida, sugarcane is normally planted during the months of October through January. Although this period coincides with the area's dry season, rainfall events exceeding 5-cm are not uncommon. Sugarcane fields have been observed to remain saturated for several days to several weeks following such rainfall events. A field experiment was conducted to investigate the impact of such conditions on the initial stand establishment of several different cultivars.

Four cultivars planted on three different planting dates, each separated by 2-week intervals, were subjected to either flooded or drained field conditions subsequent to planting. Flooded conditions were initiated six days after the last planting and were maintained for 10 days. The factorial experiment was planted in a split-split plot design with flooding as the main plot factor, planting date as the subplot factor, and cultivar as the sub-subplot factor with six replications of each treatment.

Flooding field conditions had an overall negative influence, reducing stands by an average of 14.5, 51.4, and 43.4 percent in the first, second, and third plantings, respectively. A significant flooding X planting date X cultivar interaction was observed, indicating a differential response by cultivars in various stages of germination to flooded conditions. Flooding had its greatest impact on stands of the more rapid germinating cultivars included in the experiment, CP 80-1827 and CL 73-239, at the last planting date. In contrast, flooding exerted its greatest influence on stand establishment of the slower germinating cultivars CP 72-1210 and CL 61-620 during the second planting date. These results suggest that in attempting to predict the magnitude of the negative impact of saturated field conditions shortly after planting, it is important to consider the cultivar and to know the actual stage of seedpiece germination rather than simply considering the planting date.

Effect of Flooding on Selected Sugarcane Clones and Soil-borne Insects

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Previous studies conducted on small plots indicated that some sugarcane genotypes are more productive than others under flooded conditions. In addition, flooding can control soil-borne insect pests, but control depends upon duration of flooding. This experiment was conducted to verify observations made regarding cane production in small, flooded plots. Eight sugarcane clones were selected for their ability to produce a ratoon crop after being flooded during the plant-cane crop. Clones were planted in replicated, two-row, 5x3m plots and grown for 2 crop years under flooded conditions and in a non-flooded control. Plots were flooded for about 5 months each year. Whole plot weights of cane were recorded, and insect larvae of *Lygirus subtropicus* and *Melanotus communis* were also monitored. Results showed that some sugarcane genotypes are capable of maintaining a moderate level of production in ratoon after being flooded, but others are much less tolerant of flooding. *Lygirus* grubs were controlled after one week of flooding, but *Melanotus* required 4-6 weeks for control.

Recurrent Selection for Cold Tolerance of Sugarcane

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Most commercial sugarcane cultivars do not have adequate cold tolerance to grow in the subtropical regions, but there are some clones of Saccharum spontaneum from the high latitudes show considerable tolerance to low temperatures. Attempts at transferring the cold-tolerant genes from these S. spontaneum clones to commercial cultivars by using interspecific hybridization have not been very successful because of the loss of cold tolerance during the nobilization process. Experiments were initiated to determine the effectiveness of recurrent selection for improving cold tolerance of commercial sugarcane cultivars. Clones obtained from backcross progenies (BC_1) of commercial sugarcane x S. spontaneum hybrids and from biparental crosses among the cold-hardier commercial cultivars were evaluated under natural freeze conditions at Gainesville, Florida. The measurement of cold tolerance was based on the estimated green leaf area following the natural freezes. The results from two-year tests indicated that both populations had low heritability of the cold tolerance. The frequency of clones exceeding the commercial check, NCo310, in cold tolerance rating was 3.85% for the commercial sugarcane x commercial sugarcane population and 12% for the BC_1 population from commercial sugarcane x S. spontaneum hybrids. Thus, the frequency of obtaining superior cold-tolerant clones from commercial crosses was very low. More cycles of recurrent selection are needed to determine if the improvement of cold tolerance can be achieved by using the commercial sugarcane gene pool. The BC_1 clones from commercial sugarcane x S. spontaneum hybrids did show considerably higher frequency of cold-tolerant clones, but these clones were low in sugar content and high in fiber content. A combined recurrent selection technique using both commercial sugarcane and S. spontaneum gene pools may help prevent the loss of the cold-tolerant genes during the process of nobilization and result in new commercial cultivars with improved cold tolerance.

Releases of Horismenus elineatus for Lesser Cornstalk Borer Control in Florida Sugarcane

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Multiple releases were made in Florida sugarcane fields during December, 1991, through April, 1992, of Horismenus elineatus Schauff (Hymenoptera: Eulophidae), an internal parasitoid of the lesser cornstalk borer, Elasmopalpus lignosellus (Zeller) (Lepidoptera: Pyralidae). Originally from Bolivia, this host-specific parasitoid has been released in Hawaiian cane fields, where 25% or more borers are now often killed by the parasitoid in some individual fields. About 7,800 H elineatus from Hawaii were released directly into Florida cane fields, and about 1,200 from Hawaii were used to establish a laboratory colony of the parasitoid. This colony facilitated a number of additional releases in Florida. Overall, a total of 9,400 parasitoids were released across seven general areas around Clewiston in Palm Beach and Hendry counties. Specific cane fields where H. elineatus was released were infested by the lesser cornstalk borer. The parasitoid was recovered from 3 borers collected in January near one release site. However, of 134 borers collected during March from cane fields in the vicinity of release sites, no parasitoids were recovered. Whether or not H. elineatus becomes established in Florida sugarcane remains to be seen. The author acknowledges and thanks Dr. Fred Bennett, Dr. Joe Funderburk (both with the University of Florida), Dr. Asher Ota (Hawaiian Sugar Planters Association), Dr. Lim Nong (Florida Department of Agriculture, Division of Plant Industry), and Dr. Jim Smith (Texas A&M University) for their contributions to this project.

Response of Sugarcane Germplasm Clones to the Sugarcane Borer

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Sugarcane (interspecific hybrid of Saccharum spp. L.), germplasm clones were evaluated for their response to sugarcane borer (Diatraea saccharalis F.). These germplasm clones were important as they were identified among progeny of varieties identified as resistant to the sugarcane borer. As such, they represent another cycle in a recurrent selection program for increasing sugarcane borer resistance in commercial varieties. Evaluations were made in a series of experiments conducted over a five year period.

Initial evaluations began with spaced single stools established from seedlings planted in the spring of 1987. Sufficient insect pressure was created by intercropping the seedlings with corn (Zea maize L.) artificially infested with sugarcane borer larvae. Seedlings were considered resistant when visual inspection detected little borer damage, i.e. absence of broken stalks and absence of the premature germination of lateral buds. Seedlings selected as resistant were clonally propagated in 1988 in unreplicated, single-row, 1.8 m plots. Sufficient borer pressure was again achieved by intercropping cane with infested corn; clones continuing to express resistance to sugarcane borer were identified by visual inspection of plots.

Final selection was made in the plant-cane crop (artificially infested) and first-stubble crop (naturally infested) of a test containing 46 selections. Selections were established in single-row, 1.8 m plots replicated four times. Damage ratings were based on a 1-9 scale where a rating of 1 indicated little damage and a rating of 9 indicated extensive damage.

Ward's minimum-variance cluster analysis was used to assign germplasm clones to one of four discrete groups. Percent damaged internodes and damage rating data from both the plant-cane and first-stubble crops were included in the cluster analysis. Five germplasm clones, US 90-18, US 90-21, US 90-24, US 90-26 and US 90-27 were assigned to either cluster group 1 or 2. Mean % damaged internodes and damage ratings, both in plant-cane and first-stubble, of cluster groups 1 and 2 were less than the overall means of all clones tested for plant-cane % damaged internodes (4.3%) and damaged ratings (2.9), and first-stubble % damaged internodes (8.2%) and damage ratings (3.5). Cluster group 1, containing the germplasm clones US 90-18, US 90-24, and US 90-27, sustained an average of 2.6% damaged internodes and an average damage rating of 1.8 in the plant-cane crop. In the first-stubble crop, cluster group 1 averaged 3.2% damaged internodes and a damage rating of 2.3. The germplasm clones US 90-21 and US 90-26 were assigned to cluster group 2; a group averaging 2.6% damaged internodes and an average damage rating of 2.5 in the plant-cane crop and 7.0% damaged internodes and a damage rating of 2.9 in the first-stubble crop. Both cluster group 1 and 2 expressed higher levels of resistance to sugarcane borer than cluster group 3 containing the resistant standard CP 70-321.

The five resistant germplasm clones had yields of sugar/hectare comparable to the commercial standards CP 70-321 and CP 74-383 and appeared resistant to the spread of sugarcane mosaic virus and smut. These five germplasm clones have been submitted for registration by The Crop Science Society of America.

Sampling of Sugarcane Fields for Wireworms (Coleoptera: Elateridae)

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Wireworms are a major pest of sugarcane in Florida. Their control, mainly through the routine application of insecticides at planting, costs approximately $55.00/ha. However, there is little information on sampling for wireworms in sugarcane, thus it is possible that many fields are treated unnecessarily at considerable expense to the grower and to the environment. A total of 65 samples were taken from each of 6 fields equidistantly 60.8 m along rows number 2, 30, 60, 90, and 120; 13 samples taken from each row. The mean number of wireworm per sample (61 cm long X 61 cm wide X 26 cm deep), ranged from 6.02 ± 3.46 SD to 16 ± 6.61 SD with an overall mean of 11 wireworms (118,408 per ha). Sampling cost was estimated at $13.00/ha, so that if insecticide application is avoided in one of five fields, the savings would pay for the sampling of four fields. Most sugarcane is planted successively, i.e. a field is cultivated and replanted soon after the harvest of the last ratoon crop. Although it is not known what effect cultivation practices have on wireworm mortality, sampling of crops in their final ratoon crop could help determine whether an insecticide application is warranted at planting.

Increased Incidence of Leaf Scald Disease in Florida Associated with a Genetic Variant of *Xanthomonas albilineans*

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In the past several years, an unexpected increase in the incidence of leaf scald disease of sugarcane in Florida prompted investigation of the possibility that genetic variation of the pathogen might be involved. Seventeen strains of *X. albilineans* isolated from sugarcane in Florida at different times and locations over the past 25 years were examined for differences in DNA patterns following restriction endonuclease digestion and separation of the restriction fragments by pulsed-field gel electrophoresis. The strains could be placed into two groups, A and B, based on restriction digest patterns. The seven strains of group A were all from sugarcane grown at the U. S. Sugarcane Field Station at Canal Point, Florida. The year of isolation of group A strains ranged from 1967 when leaf scald was first recognized in Florida to 1989. Although the restriction digest patterns of the group A strains were similar, some polymorphisms were detected suggesting that minor mutations had occurred over the years. The 10 strains in group B were from sugarcane grown at various locations throughout the sugarcane production area in Florida from 1989 to 1991. No polymorphisms were detected in the restriction digest patterns of group B strains suggesting that they might have had the same origin. Leaf scald was rarely observed outside of the U. S. Sugarcane Field Station prior to the late 1980's and almost never in commercial cultivars. The results of this study support the contention that the recent outbreak of leaf scald is due to the introduction into Florida of a pathological variant of *X. albilineans*.

Environmental Considerations for Insecticide Research on Sugarcane

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Selecting insecticides for research and further consideration toward labeling of chemicals for pest control in sugarcane at LAES involves an 8 criteria evaluation system emphasizing environmental protection as well as stable long-term pest control. Within the context of integrated pest management, these assessments include: a) effects on non-target arthropods, particularly key beneficials, b) toxicity to fish, birds, and selected other wildlife, c) hazard to the applicator, and d) additional practical considerations related to developing a permanent pest management system.

Discussion of the importance of various criteria includes not only data of legitimate environmental concern to the public, but also the public perception of threats in the sugar industry. From the entomological and interdisciplinary pest management perspective, data will be presented which demonstrates pragmatic and specific efforts to deal with those concerns in southern agriculture.

Relationship Between Climatic Factors and Flowering Time in Sugarcane

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The two main objectives of this study were to determine the relationships between six climatic factors and flowering time in sugarcane (Saccharum spp.) and to explore the feasibility of forecasting flowering time of some important varieties used as parents. The data used in the statistical analyses included the natural flowering dates of six parents (CP 72-1210, CP 65-357, CP 70-1133, CP 72-370, CP 74-383, and CP 72-356) and six climatic factors during the past 23 years (from 1969 to 1991). The climatic factors were: average minimum temperature from November 1 to November 15, average minimum temperature in October, total rainfall in October, rainy days in October, total rainfall from August through September and rainy days from August through September. Three models were fitted: the complete model included all six climatic factors and two reduced models obtained by stepwise regression. All reduced models were significant at $P = 0.05$ and only included those factors which had significant effects on the flowering dates. A reduced model was also tested with individual components significant at $P = 0.15$. The general and reduced models over all varieties were significant at $p = 0.01$. General and reduced models were also calculated for each variety. This study showed that the average minimum temperature in October had the largest effect on flowering dates, followed by rainy days in October. Increasing night temperature and applying sprinkler irrigation in October should induce most varieties to flower earlier than usual.

A Mapping Management System

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Louisiana

Two years ago, A. V. Allain and Sons began developing a set of computer land maps. Auto-cad is the software we have used. The resulting geographical maps have been very useful from a management standpoint. The maps have been excellent for recording and evaluating data from soil tests as well as fertilizer, yield, and other information.

Influence of Sugarcane Topping on Stalk Weight and Sugar Yield

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There has been considerable discussion in recent years regarding the proper setting of the topper blade on whole-stalk, soldier harvesters to maximize the yield of sugar per acre. A field experiment was conducted on December 3, 1991 in the plant-cane crop of 4 sugarcane cultivars, CP 65-357, CP 70-321, CP 72-370, and CP 74-383, to study the effects of topping height on stalk weight and the yield of theoretical recoverable sugar per ton of cane (TRS or sugar yield). Two hundred forty mature stalks of each cultivar were serially selected along the row in standing cane, cut only and the base, stripped of leafy trash, and removed from the field with the tops intact. Stalks of each cultivar were divided at random into four, 60-stalk samples. Stalks in each sample were topped at one of the following four heights (treatments): 1) Two (2) in. above the apical meristem (bud); 2) Four (4) in. below the bud; 3) Ten (10) in. below the bud; and, 4) Sixteen (16) in. below the bud. Each treatment was divided into six subsamples containing 10 stalks each (replications). Subsamples were weighed to determine stalk weight and analyzed using the press method to estimate sugar yield.

Differences were noted in both stalk weight and sugar yield as an average of all varieties as a result of the height of topping. Stalk weight decreased 4.9% and sugar yield increased 2.5% with each 6 in. lowering of the topping height. These results indicate that the height of topping has a greater impact on lowering stalk weight than increasing sugar yield. As topping heights were successively lowered, the cultivar CP 70-321 had the greatest decrease in stalk weight (-0.18 lb) and CP 65-357 the smallest (-0.05 lb). With respect to sugar yield, the cultivar CP 74-383 had the greatest increase (7.7 lb) and CP 65-357 the smallest (2.5 lb). The component of juice quality most affected by topping was juice purity; purity improved as topping was lowered. Fiber content remained essentially the same at all heights of topping.

By combining the effect of topping on both stalk weight and sugar yield and assuming a constant number of stalks per acre, maximum yield of sugar per acre was obtained for both CP 65-357 and CP 70-321 by topping 2 in. above the bud and for CP 72-370 and CP 74-383 by topping 4 in. below the bud. However, because of other non-sugar solids, i.e. starch, polysaccharides, etc., found in the top 2 to 4 in. of the stalk, it is suggested that the level of topping be no higher than 4 in. below the bud. Additional studies are needed to determine the proper level of topping early in the harvest season when the cane is less mature.

Louisiana Sugarcane Planter Tests: 1989 & 1990

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Tests were conducted during the fall of 1989 and 1990 on planting methods including hand planting and several designs of mechanical planters to determine planter performance by measuring seed rate and rate consistency, seed piece damage, and overall planter operations. A standardized test procedure was adopted using modifications of earlier studies conducted by Dunckelman and de Beauclair (1983) and Parish, Chaney and Baker (1987). The data collected during 1989 and 1990 as compared to earlier tests would indicate some progress has been made in reducing seed rate with mechanical planters thus coming closer to simulating the seed rate of hand planters. Additionally, some improvement was evident in terms of seed piece damage. Further reductions in the seed rate of mechanical planters should come about only with accompanying reductions in seed piece damage otherwise too few surviving eyes could reduce spring stands of sugarcane.

Pumping Requirements for Subsurface Drainage Systems in South Louisiana

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Subsurface drainage has the potential to increase crop yields, enhance trafficability, and reduce surface runoff. Farmers, however, are reluctant to install subsurface drainage systems because of high initial costs, uncertain operating costs, and unpredictable prices of farm products. Since annual rainfall frequently exceeds 60 inches and the water table fluctuates near the soil surface for long periods each year, farmers are concerned about the operating costs of subsurface drainage systems that require sumps as drainage outlets. Water drained from Jeanerette silty clay loam, Commerce silt loam, and Baldwin silty clay soils planted to sugarcane in south Louisiana was measured during 1979-1992. At each location, subsurface drains emptied into sumps where pumps discharged drain outflow through water meters into surface drainage canals. Water meter and electricity meter readings were recorded periodically during the test period. Water drained from the Jeanerette soil during 1981-1990 averaged 24 acre-inches per year. Pumps used 189 kwh of electricity to discharge this water into a drainage canal at a cost of $15/A annually, assuming electricity costs were eight cents/kwh. Water drained from the Commerce soil during 1979-1989 averaged 11 acre-inches per year. Pumps used 119 kwh of electricity to discharge this water at an annual cost of $10/A. Water drained from the Baldwin soil during 1982-1992 averaged three acre-inches per year. Pumps used 23 kwh of electricity to discharge this drainage water at an annual cost of $2/A. Base flow existed at both the Jeanerette and Commerce soil sites but the base flow was more at the Jeanerette site. Average annual rainfall was 63, 61, and 67 inches at the Jeanerette, Commerce, and Baldwin soil sites, respectively. Increases in sugar yield due to subsurface drainage averaged 19, 9, and 6 percent annually from the three soils, respectively. These increases were valued at $113, $64, and $46 per acre at today's raw sugar price of 22 cents/lb, less milling costs.

Fungicidal Control of Puccinia melanocephala on Sugarcane

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Cultivar resistance is the sole economically feasible control measure presently available for sugarcane rust, caused by Puccinia melanocephala. The objective of this experiment was to evaluate the efficacy of two fungicides for rust control and to examine their subsequent influence on yield.

The fungicides mancozeb and propiconazole were foliarly applied to plant-cane of the rust susceptible cultivar CP 72-1210 at 7-day and 14-day intervals during spring 1991. In an additional treatment, the two fungicides were alternately applied on a 7-day schedule. Fungicide applications were initiated in March and continued through May. Environmental conditions were favorable for rust development during March and early April and disease pressure was high at this time. However, above normal temperatures during late April and May created repressive conditions for rust development and disease pressure subsided earlier than normal.

All fungicide treatments provided for significant reductions in rust severity. However, treatments containing mancozeb, regardless of the application interval, were more effective in controlling rust than those receiving only propiconazole. Similarly, only treatments containing mancozeb provided for significantly higher cane yields per hectare when compared to the untreated check. These results are somewhat surprising in light of the proven efficacy of propiconazole in controlling rust diseases caused by the genus Puccinia on other crops.

The Economic Impact of Succession Planting and a Third Ratoon Crop on Efficiency in Sugarcane Production

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The dynamic nature of sugarcane production costs coupled with fixed administrative prices for raw cane sugar have encouraged many producers to search for alternative rotation production practices. Linear programming techniques were used to develop a simulation model of a typical Louisiana sugarcane farm, within a framework of constraints typically found in the Louisiana sugarcane producing region. The structure of the farm reflects the most efficient organization as identified by previous research that addressed production efficiency and supply response of commercial sugarcane farms in Louisiana. The analysis has been expanded to evaluate the efficiency of succession planting and a third ratoon crop as rotation alternatives in sugarcane production. Results identify labor and non-land capital requirements and economic indicators that measure production efficiency (cost/income ratio, pounds of sugar produced) and standard financial measures such as direct costs, total costs, net income. The efficiency measures derived from incorporating succession planting, a third ratoon crop, and a combination of both were compared with the efficiency measures of a standard rotation. It must be emphasized that the standard rotation was nondeterminate in that the rotations were selected by the linear programming model as it attempted to meet its profit maximization objective.

Herbicide Treatments for Bermudagrass Control in Fallow Sugarcane Fields

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Studies were conducted in Louisiana to evaluate the use of herbicide treatments in fallowed sugarcane fields to control bermudagrass; a weed not easily controlled within the crop. The sugarcane stubble in the study sites was destroyed by disking following the fall harvest of the second-ratoon crop. Sites were disked periodically to destroy seedling weeds and vegetative propagules until the 1.8 m wide sugarcane beds were reformed in late-May. In the first study, conventional opening and closing of the reformed beds (mechanical weed control) was compared to treatments where preemergence herbicides were applied alone or in combination with a follow-up postemergence application of glyphosate. In the second study, postemergence control of bermudagrass with glyphosate was compared to other postemergence herbicides. In both studies, treatment effectiveness was based on bermudagrass infestations and sugarcane shoot counts in December following sugarcane replanting and on the growth and yield of the subsequent plant-cane crop.

In the first study, 48% (44% control) of the replanted row was infested with bermudagrass where beds were opened and closed at 3- to 4-week intervals (three times during the June through August fallow period). Infestation levels were reduced to 19% where a broadcast application of glyphosate at 3.4 kg ai/ha replaced the third tillage operation. Preemergence applications of atrazine, metribuzin, and sulfometuron were ineffective in controlling bermudagrass. However, imazapyr applied alone at 0.6 and 1.1 kg ai/ha reduced bermudagrass infestation levels to 46 and 21%, respectively.

Plots receiving two postemergence applications of glyphosate at 3.4 kg/ha or preemergence applications of atrazine or metribuzin followed by a postemergence application of glyphosate at 3.4 kg/ha 2 to 3 weeks prior to replanting had the lowest after-planting bermudagrass infestation levels. Theoretical sugar yields in the plant-cane crop increased from 6872 kg/ha (tillage only) to 8243 kg/ha where glyphosate was substituted for the final cultivation to 8680 kg/ha in plots treated with sequential applications of glyphosate.

In the second study, bermudagrass allowed to develop on reformed beds during the fallow months covered 80% of the replanted row surface in December. Infestation levels in plots treated on July 20, with glyphosate at rates of 1.7 to 3.4 kg/ha averaged 22%. Similar reductions in bermudagrass infestation levels were observed in plots treated with the graminicides, fluazifop-P and quizalofop at 0.2 kg/ha. The growth and development of the subsequent plant-cane crop was suppressed where bermudagrass was not controlled. Of the postemergence treatments evaluated, increases in harvestable stalk number (12%), height (13%), and weight (19%); theoretical sugar recovery (9%); and yields of cane (34%) and sugar (48%) were greatest in plots treated with glyphosate at 2.2 or 3.4 kg/ha.

The results suggest that substituting the last tillage operation prior to sugarcane replanting with a postemergence application of glyphosate reduces bermudagrass infestation levels and increases sugar yields in the subsequent plant-cane crop. With two postemergence applications of glyphosate or a preemergence application of atrazine or metribuzin followed by a postemergence application of glyphosate 2 to 3 weeks prior to replanting, fallow field tillage can be eliminated. An alternative to the use of glyphosate for the postemergence control of bermudagrass in fallowed fields was not found.

Water and Nitrogen Management Effects on Yields of Sugarcane Grown on Sandy Soil

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Sugarcane (Saccharum spp., var. CP 72-1220) was planted in September 1990 and grown in a commercial field on sandy soil in southwest Florida to investigate biomass accumulation and yield effects of the following treatments: 1) Water table depths of 48 and 65 cm below the soil surface; 2) Nitrogen fertilization frequencies of 3 and 5 split applications/season (total of 224 kg N/ha applied); and 3) Mg fertilizer rates of 0 and 67 kg/ha. Soil water potential measured at 10, 20, and 30-cm depths did not differ between water table level treatments. However, soil water content in the upper root zone (top 0-30 cm of soil) was 0.06 cm^3 cm^{-3} lower in the low water table treatment. Although the high water table favored greater dry matter accumulation in October 1991 (17.9 vs. 16.2 Mg/ha), there was no difference in sugarcane yield (mean 93.2 Mg/ha) or sucrose yield (mean 12.1 Mg/ha) between water level treatments at harvest in March 1992. There was no effect of N fertilization frequency or Mg level on dry matter accumulation, sugarcane yield, or sucrose yield. Small plot (0.012 ha) yield estimation was compared to large plot (1 ha) commercial yield measurement. Simple linear correlation coefficients (r) for sugarcane yield, sucrose concentration, and sucrose yield were 0.62, 0.65, and 0.41, respectively.

Ratoon Stunting Disease in Florida's Non-hot-water Treated Sugarcane Seedfields

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RSD field infection of cultivars in commercial sugarcane seedfields that have not had any hot-water-treatments to eradicate RSD ranged from 0 to 100% with most fields having a high incidence of infection. The newest cultivar, CP 82-1592, had the lowest mean incidence of RSD with 1.9% stalks infected; while, cultivars, CL 61-620 and CP 72-1210 had 100% of the stalks infected. The mean number of RSD colonized vascular bundles ranged from 0.06 in cultivar CP 82-1592 to 10.8 in CL 61-620. The differences in mean number of colonized vascular bundles suggests cultivar differences in RSD susceptibility. There was a correlation ($r = 0.76$) between the mean number of colonized vascular bundles and field incidence of the disease.

Multiple Comparison Procedures in Sugarcane Research

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Many articles and presentations of the American Society of Sugar Cane Technologists use multiple comparison procedures. These procedures determine significant differences between members of pairs from all possible pairs within an experiment. Statisticians have shown that the least significant difference (LSD), attributed to R. A. Fisher, performed regardless of the results of a preliminary F test (unprotected LSD), approximates the researcher's chosen significance level more closely than all other multiple comparison procedures. When a researcher determines that a multiple comparison procedure is appropriate, he/she should use the unprotected LSD. A survey of agricultural articles published in this Society's Proceedings and Journals since 1971 found 178 articles that used at least one statistical procedure. Of these, 124 used a multiple comparison procedure. Only 18 of these 124 articles used the unprotected LSD. One objective of this presentation is to illustrate the importance, to growers, extensionists, and researchers, of using a statistical procedure that closely approximates the researcher's chosen significance level. A second objective is to show the magnitude by which various multiple comparison procedures, other than the unprotected LSD, change the chosen significance level.

Evaluation Efficiency of the Louisiana Outfield Sugarcane Testing Program

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The "outfield" is the final stage of testing experimental sugarcane varieties in Louisiana. The tests are conducted on commercial sugarcane farms by personnel of LSUAC, USDA-ARS, and ASCL in accordance to the "three way agreement of 1978". Recommended varieties have traditionally been included in the outfield test. The nature of the tests dictates uniform management of all varieties in the test. Since the individual varieties in these tests can not be managed for the best estimate of commercial potential, it could be argued that commercial varieties should be included for check plots only. Reduction in the number of commercial varieties should lead to increased test precision or allow inclusion of additional experimental varieties. The breeders' goals for this stage of testing are to evaluate experimental varieties for yield potential and suitability for mechanical harvesting. Plant breeding studies consistently show advantages in early testing among locations. It is suggested reallocation of resources from the outfield testing stage to early testing stages would enhance the development process. This would effectively reduce the number of outfield testing locations. Analysis of plantcane sucrose per hectare yields of three replication tests for the years 1989 and 1990, showed that 94% of the potential genetic gains achieved with 13 locations could be made by using a three replication - seven location testing situation. Correlations among locations of mean location sucrose per hectare yields showed no consistent pattern when analyzed on a single year basis for 1988, 1989, and 1990 tests. Consistent variety by soil texture responses could also not be demonstrated. The results suggested yearly location differences are largely influenced by local weather and weather by soil by management interactions. Thus, variety recommendations based on soil type could not be supported by the "outfield" data. The results indicate that no more than eight carefully selected locations are needed for outfield tests. Reducing the number of outfield tests could facilitate redirecting man-hours to evaluate newer experimental varieties at earlier selection stages at additional locations.

The History of Outfield Sugarcane Variety Testing in Louisiana

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Louisiana outfield variety testing was initiated because the sugarcane specialist felt that the data generated at the Sugar Experiment Station in Kenner did not represent the sugar belt as a whole. In 1924 Dr. W. R. Dodson, Director of the Louisiana Agricultural Experiment Station, conceived an idea of establishing test field locations throughout the state to test experimental varieties over the range of soil, weather, and farm management conditions under which commercial varieties were grown. After receiving support from the LSU Board of Supervisors to use LAES funds, Dodson took his plan to the American Sugar Cane League in the fall of 1924. Five large plantations were selected as locations for the test sites. In the fall of 1926, representatives of the Louisiana Agricultural Experiment Station, the U. S. Office of Sugar Plants, and the American Sugar Cane League adopted a standard plan for testing varieties on the test fields. The plan consisted of planting the varieties in four to ten replicates of one-twentieth of an acre plots on three rows. Mill tests would consist of four-ton samples which would be milled without maceration. Handmill samples would be performed at regular intervals, starting in October and extending through the grinding season.

By 1934 the number of LAES supervised test locations reached nine. By 1938 the farm labor supply had begun to dwindle. The first effect of reduced labor supply was a reduction in plot size. In 1944 the outfield test consisted of thirty-nine varieties, of which nine were commercial field canes and the others were advanced experimental varieties.

In 1946 the original plans for testing were abandoned and a new plan was adopted. Because of the increased number of varieties, the tests were divided into three groups through which newly introduced varieties were placed and later they progressed to being tested with commercial varieties. With the necessity of mechanical harvesters, tests were performed on cane erectness, resistance to lodging and other characteristics believed necessary for satisfactory use of machines.

Prior to 1955, the LAES and the USDA-ARS supervised their respective outfield locations and reported results independently. In 1955 the efforts were consolidated and after 1958 the results were printed as one. There were twelve outfield locations throughout the sugar belt on which thirty-three sugarcane varieties were tested.

The outfield tests of today differ in many ways from the original tests of 1925. Many changes were made due to advances in knowledge and technology. All were driven by a dwindling supply of resources (particularly available labor). These forces are affecting the variety development program today.

MANUFACTURING ABSTRACTS

Use of Immobilized-Enzyme Electrodes for Sugar Analysis

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The current analytical method of sugar analyses at the Clewiston Sugar House Laboratory, U.S.S.C., Florida involves, first: the separation of impurities from the sample by physical (ultrafiltration) or chemical means, and second: reading its Polarization in an automatic Polarimeter.

During the crop 1989/90 an instrument based on immobilized enzyme technology was bought for expediting water analysis of low sugar content. This particular instrument provides results in less than 2 minutes per sample, can be loaded with up to 24 samples, runs automatically, and requires no sample preparation.

Because of the simplicity of operation of the instrument and of its built-in capabilities for process control, it was decided to run a comparison study between the Polarimetric and the enzymatic analysis of sucrose using samples representing all range of intermediate and final products coming from the Boiling House and Milling Station.

Our preliminary results showed less than 1% difference between procedures for some sample, and about 2 to 5 percent difference on others. It is felt at this point, that if a margin of difference between the two methods is accepted, the instrument using immobilized enzymes could be used for routine analysis in the lab, and also could be installed on line for process control.

The details of this study and recommendations are given in this report.

The Efficiency of Bagasse Fired Boilers

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This paper discusses the factors affecting the efficiency of bagasse fired boilers. Plots are presented to show the effect that moisture % bagasse, flue gas temperatures and excess air have on boiler efficiency, furnace temperature, etc. Results of actual boiler tests collected at Louisiana sugar factories in 1990 and 1991 are also presented.

Vee Wire Trommel Assemblies for the Primary Separation of Juice from Fibre in the Milling of Cane Sugar

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This paper addresses the design and development of vee wire trommel assemblies and their benefits compared to the use of DSM screens and, in particular, cush-cush drags. Benefits include the ability to clean the screen surface during continuous operation, its efficient separation process, and significantly greater throughput.

Planning and Recording of Pan Floor Operations

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The presentation of this paper shows how we run our operations of the Pan-Floor at Caldwell Sugar Factory in the form of graphs.

The factory does not manufacture sucrose. Sucrose is made in the cane by a complex biological process, and it is the factory's duty to extract the maximum amount in the form of commercial sugar of the desired quality. If cane juice consisted only of pure sucrose and water, the process would be a relatively simple one; but this, however, is not the case, since juice contains a number of substances other than sucrose - which complicate matters and prevent all of the sucrose from being recovered.

We first plan our operations according to existing conditions: The quantity and quality of syrup coming from the evaporators; materials present in the pans, tanks, seeders, mixers, etc. The planning is done first in the form of graphs. After dropping the massecuites from the pans, the recording is done by noting the grade, volume and time of each strike - also in graphs.

Starch, Polysaccharide and Leucoanthocyanin Pigments in Sugarcane Varieties Grown in Louisiana

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Starch and total polysaccharide (TPS) are important quality factors in processing because they are difficult to remove, may contribute to viscosity, can decrease filtration rates, and are preferentially included in sugar crystals, thereby contributing to color and turbidity. Leucoanthocyanins (LUA) are red pigments attached to polysaccharides that may contribute to the disease-fighting abilities of sugarcane plants. Ten commercial sugarcane varieties were tested for starch, total polysaccharide and leucoanthocyanin during the 1990 crop in Louisiana. Sample dates were October 1, October 15, November 13, and December 10, 1990.

A preliminary study on the 1989 crop had indicated that varieties differ in starch concentration, but the data were inconclusive. In this study, the trends were much clearer, showing that varieties differed significantly in starch, total polysaccharide, and leucoanthocyanin pigments. As in the previous study, CP 72-370 was highest in starch, and CP 70-321 was the lowest. CP 72-370 also had the highest TPS and LUA concentration; CP 70-321 was lowest in TPS and ninth in LUA. Polysaccharide content increased dramatically in November in all varieties. The increase coincided with a late surge of growth during a period when daily air temperatures were high and rainfall was heavy. In general, TPS increased over the season and starch decreased as the harvesting season progressed. However, varietal differences were considerably more pronounced than seasonal differences.

A Zero Effluent Scheme for Ion-Exchange Softening of Clarified Juice

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Louisiana Agricultural Experiment Station
LSU Agricultural Center
Baton Rouge, Louisiana

The removal of calcium ions from clarified sugarcane juice can soften the juice to reduce scale on heating surfaces and improve raw sugar quality. If the molasses is to be further processed by ion-exclusion, it is also necessary to decrease the calcium concentration.

Calcium ions were removed from clarified juice by treatment with a carboxylic cation exchanger in the hydrogen form at 90°C at a flow rate of up to 150 bed volumes per hour. Effluent juice needs to be neutralized with sodium hydroxide. The resin was regenerated with phosphoric acid with the intention of adding the spent phosphoric acid to the mixed juice, thereby improving the initial clarification. In our experiments the resin was saturated with calcium after about 350 bed volumes of juice. The calcium concentration was below 50 ppm on brix for 150 bed volumes and their average concentration in the effluent juice was less than 70 ppm when the resin was exhausted to the point of leakage. Experimental data and potential application of this system will be described.

The Influence of Cane Quality Upon Pol Extraction

Luis R. Zarraluqui
Sugar Cane Growers, Cooperative of Florida
Belle Glade, Florida

Pol Extraction for a given milling train depends primarily on the quality of the cane it crushes. Sixty years ago, DEERR derived a formula to eliminate the influence of variations in fiber, reducing the extraction to a common basis of 12.5 percent fiber in cane. That Figure, called "Reduced Extraction", is still reported daily by most sugar mills, being intended to compare efficiencies. Should fiber be 12.5 percent in cane, then the Reduced Extraction would equal Pol Extraction.

However, how fair is it to compare milling trains crushing two different cane varieties, both 12.5 percent fiber in cane, but one of them, for instance, 11.0 percent pol in cane, and the other, say, 14.0 percent pol in cane? Obviously, in order to have a valid index to compare milling efficiencies, the influence of varying pol must also be eliminated. If we define cane quality Q as the ratio Pol % Cane/Fiber % Cane, it can be shown that:

$$E_{RR} = 100 - Q(100-E)/e^{(Q-1)(\text{Bagasse \% Cane}/100)}$$

where E_{RR} is Extraction Reduced to the basis of 12.5 percent fiber in cane, and 12.5 percent pol in cane, E is the Extraction obtained with cane of quality Q, and e is the base of the natural logarithms.

As a matter of fact, the influence of cane quality extends well beyond the milling train, pervading the boiling house, and the power house, as well. The paper contains the derivation of the foregoing formula, along with the author's views on some controversial issues.

Cane Molasses Desugarization Program at Audubon Sugar Institute

Michael Saska
Louisiana State University
Baton Rouge, Louisiana

The SMB chromatography pilot unit at Audubon Sugar is described and results are presented of our continuous desugarization tests with Louisiana molasses. These are used to validate our staged dynamic theoretical model of the SMB separation. Although adsorption of the principle molasses components is somewhat non linear, our model is capable of accommodating this, and it appears that representing sugarcane molasses as a four-component linearly adsorbing mixture is adequate. Running the model on any fast personal computer, one may then optimize the separation parameters such as the size of the columns, flow rates, etc. Moreover, the model allows for an easy evaluation of alternate arrangements such as installation of a third product outlet port that will in the case of sugarcane molasses contain predominantely invert, and betaine in the case of sugarbeet molasses containing betaine.

Discussion is also provided of our progress on posttreatment processes, an ion exchange decolorization of the SMB extracts, and a pretreatment process, a necessary step designed to lower feed hardness and produce an optically clear feed to the SMB separator.

Turbidity Measurements on Raw Sugar

Ludlow Brown
Sugar Industry Research Institute
Factory Technology Division, Bernard Lodge
Jamaica, West Indies

Stephen J. Clarke
Audubon Sugar Institute
Louisiana Agricultural Experiment Station
LSU Agricultural Center
Baton Rouge, Louisiana

A comparison has been made of nephelometric and spectrophotometric techniques for the measurement of turbidity in sugar processing liquors and for raw sugar. There is considerable variation in data, with fairly good correlation when a membrane filter was used for preparation of the blanks for the spectrophotometric measurements.

The nephelometric system was used to measure the performance of several clarifiers and can give useful information for assessing the clarifier performance. Results and preliminary conclusion of these tests will be described.

Preventative Maintenance in Different Rolls and Its Benefits

Moacir Prisco
Sao Paul, Brazil

Different preventative maintenance programs for rollers at sugar mills in Brazil will be reviewed. Most of the findings presented were from surveys at Copersucar sugar mills. Characteristics of rolls will be addressed, including chemical composition, types of alloys, coefficients of friction, and roller wear.

The Role of Dextran in Sugar Loss to Molasses

D. F. Day
Audubon Sugar Institute, Louisiana State University
Baton Rouge, Louisiana

A severe freeze in Louisiana in 1991 provided the perfect test for determining the amount of sugar that is lost to final molasses due to dextran. The sugar lost was not only due to the dextran concentration but also to region and individual operating conditions in the factories. In all cases the amount of sugar lost was significantly higher than that reported by Australian researchers. The level of dextran that can cause significant financial loss is well below that which triggers penalty levels from sugar refiners.

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Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

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Unless the nature of the manuscript prevents, it should include the following sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION, CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized. Scientific names shall be italicized.

All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. Exactness in reproduction can be insured if electronic copies of the final versions of manuscripts are submitted. Potential authors are encouraged to contact the managing editor for specifics regarding software and formatting software to achieve ease of electronic transfer.

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Number the tables consecutively and refer to them in the text as Table 1, Table 2, etc. Each table must have a heading or caption. Capitalize only the initial word and proper names in table headings. Headings and text of tables should be single spaced. Use TAB function rather than SPACE BAR to separate columns of a table. Each table should be on a separate sheet.

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Format Example

EVALUATION OF SUGARCANE CHARACTERISTICS FOR MECHANICAL HARVESTING IN FLORIDA

J.E. Clayton and B.R. Eiland
Agricultural Engineers, SEA, USDA, Belle Glade, Florida

J.D. Miller and P. Tai
Research Geneticists, SEA, USDA, and Canal Point, Florida

ABSTRACT

INTRODUCTION

MATERIALS AND METHODS

RESULTS

Table 1. Varietal characteristics of nine varieties of sugarcane over three-year period at Belle Glade, Florida.

Figure 1. Relative size of membrane pores.

DISCUSSION

CONCLUSIONS

ACKNOWLEDGMENTS

REFERENCES

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References: Official manuals are often difficult to understand. As a result, numerous help books are published. We have found Mastering WordPerfect 5.1 by Alan Simpson, ISBN 0-89588-670-7 easy to understand and follow. The features such as tables, style appearance, and alignment are well presented in the book.

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Florida and Louisiana Divisions

September, 1994

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PRESIDENT'S MESSAGE
LOUISIANA DIVISION

Charles L. Thibaut

I am pleased to welcome my fellow members of the Louisiana Division, our friends from the Florida Division, and guests to the 23rd annual joint meeting of the American Society of Sugarcane Technologists.

A friend of mine told me that the last time he remembered having normal weather in Louisiana was when he was a young child. This friend of mine is 65 years old. The 1990 crop was devastated by the 1989 Christmas freeze, the 1991 crop suffered from excessive rain, and the 1992 crop was torn by the winds of Hurricane Andrew.

In spite of Andrew, Louisiana produced a record 880,271 tons raw value of sugar. This was not due to the yield of 4,933 pounds of sugar per acre, but rather to the largest number of acres ever harvested of 350,000. Growers reported gross cane per acre harvested of 25.7 tons per acre for total cane ground of 8,984,875 tons. We have ground more tons of cane in years past but usually because of record yields of sugarcane per acre.

Few can remember a harvest season as wet as 1992. There were only a few dry days in late September and early October. The rain and resulting muddy conditions coupled with lodged cane in many areas from the hurricane made harvesting conditions extremely poor. As a result, recoveries fell in many factories and the added expenses of cane washing and mud disposal occurred as well as reduced fuel efficiencies in the boilers. Most in Louisiana will agree that it was a year to learn from but not to brag about. It's been said that the good part about sugar and most farming enterprises is that every year there is a beginning and an end - so there's always next year.

Calvin Coolidge once said that if you see ten troubles coming down the road, you can be sure that nine will run into the ditch before they reach you and you have to battle only one of them. That has not been the case for Louisiana and the sugar industry as a whole.

Louisiana and all of the sugar industry continue to face many problems. From national issues like private property rights and environmental issues to local issues of litter and smoke management. We must always be on guard and fight to keep a balance between those that desire a pristine world in which to live at any cost (as long as it is not at their cost) and those who have a complete disregard for their neighbors and the environment.

Farmers - the stewards of the land - were environmentalists before it was "cool" to be one. It behooves us to continue our efforts at all levels to bring attention to the positive things we do to preserve our resources and be good neighbors. However, we must always, from a practical sense, be against anything that erodes our profits without reward. After all, everyone knows that if you want to preserve something, you simply leave it alone - but if we did that we, would have become cannibals to survive - again, my point is balance not extremes.

As of this writing, one of the most serious problems ever faced by the entire domestic sugar industry is the North American Free Trade Agreement (NAFTA). In its current form it will cause the demise of a substantial part of the industry as we know it.

The Bush administration secretly negotiated an agreement that we were told would not disturb the current patterns of trade. They lied.

If Mexico becomes a surplus producer by replacing the some 1.5 million tons of sugar used in soft drinks with high fructose corn sweetener, then under the agreement they would be allowed to dump that artificially created surplus in the U.S. market by year seven of the agreement. The United States made a very expensive transition from a sugar-dominated market to a sweetener market equally shared by sugar and corn sweeteners. This transition took many years and resulted in over fifty U.S. sugar processing facilities being closed and costing thousands of jobs. U.S. farmers and factory workers paid the price for this transition. Now we're being asked to pay again for the Mexican transition - is this fair? Obviously not.

The problem with NAFTA doesn't stop there. We tend to overlook that the basic problem with NAFTA is that as currently written, after 15 years there will be no border restrictions whatsoever - Mexico would have unrestricted access to the U.S. market - this will eventually devastate the domestic sugar industry.

We are being asked to compete with a country that pays their workers substandard wages and has none of the expenses of water, air, and worker protection that is mandated in this country. I'm all for free trade - but let's make it fair free trade with countries that have the same high standards of living that we have. Let's not export any more jobs from a now job-scarce country. It just doesn't make sense.

But many of our problems would fade into insignificance if we had a respectable price/cost relationship. The price we have received for our sugar for the last ten years has been more or less the same while inputs for both producer and processors have risen significantly. Margins are tighter than they have ever been. Pesticides, fertilizer, machinery and fuel costs (especially in light of the proposed BTU tax) have continued to escalate as prices remain flat. And now in Louisiana as a result of the shift from owner operated farms to tenant operations the once somewhat hidden land cost has now turned into a cash cost in the form of rent. All this leads to the obvious - in order to maintain a viable domestic sugar industry, we must receive a fair and reasonable price for our product.

The American consumer has not benefited from the reduction in the sugar price. The retail price of sugar and sugar containing products paid by the American consumer has not decreased at all during the past three years, but, in fact, has increased. Therefore, the only beneficiaries of the depressed price have been the retail merchants and industrial users of sugar who have not passed the savings on the consuming public. Those users, many of whom are among the wealthiest and most powerful corporations in the nation, have realized unfair windfall profits at the expense of American farmers and consumers.

If managed properly, the sugar section of the 1990 Farm Bill provides the tools to provide a fair price to producers at no cost to the government. At the time of this writing most of the domestic sugar industry had urged the administration to administer the sugar program as Congress had intended.

The problem is oversupply - the Marketing Allotment section of the 1990 Farm Bill must be implemented. The USDA has allowed the ending stocks to rise to 17 percent compared to an average of 14.5 percent stocks to use ratios for the last four years. The stocks are a burden on the market and the last time stocks were that high, in 1984, there were massive forfeitures of sugar to the CCC. I and many others think ending stocks should be lower. Prices to producers would improve and the potential for cost to the Treasury would be avoided. We should all urge the USDA to do what is necessary to resolve the problem of over-supply in the domestic market by implementing the marketing allotment section in the 1990 Farm Bill.

Although all of the above may sound like "gloom and doom," there are some bright spots on the horizon. In 1995, Louisiana will be celebrating the 200th anniversary of commercial production of sugar. During these 200 years, the industry has faced almost every possible disaster imaginable to mankind - from droughts to floods, hurricanes, diseases, wars, too much government, not enough government, you name it. But we have always managed to survive. I have extreme confidence in the domestic sugarcane and sugarbeet growers and processors. They are very resilient and have a way of overcoming monumental adversities. The path to recovery may not be easy, but it is well worth the efforts to maintain this most important industry. Changes that we may not be particularly fond of may be required. But just because our fathers and grandfathers were doing it a certain way does not mean that that is the only way. If we have to change the status quo to survive, change will be the order of the day.

I'm fully confident that, in the year 2093, my great-grandchildren will be meeting with your great-grandchildren in a luxury resort on Venus or Mars to sort out how to overcome the problems of the day producing sugar on planet Earth.

PRESIDENT'S MESSAGE
FLORIDA DIVISION

Raul Perdomo

First, I want to express my sincere thanks on behalf of the Florida Division of the American Society of Sugar Cane Technologists to the Louisiana Division for hosting the Twenty-Third Annual Joint Meeting in Fort Walton Beach, Florida.

This morning I plan to give you a brief summary of the production results from the recent 1992-93 crop. I will also comment on four other matters of interest: First, the progress made in mechanical harvesting; second, the use of alternate crops in fallow land; third, the trade agreements and our environmental issues; and fourth, the expected progress from field and factory areas through research and development.

The Florida sugar industry completed a long but successful crop in mid-April. One hundred and eighty-five crop days passed between the start of the first mill on October 15, 1992 and the end of crop for the last mill. Frequent heavy rains were part of the reason for the extended crop. At times they seemed like a bad joke. Despite the rains, the punch line has been this: preliminary numbers from the seven mills show that 1,680,000 short tons of 96° sugar and 94,275,000 gallons of final molasses of 79.5 Brix were made from 15,350,000 gross tons of sugar cane harvested over 427,000 acres. Yields averaged 35.9 gross tons of cane and 4.00 short tons of sugar per acre. This was the third largest crop in terms of total production, cane per acre, sugar per acre and 96° sugar percent cane over the last five years.

In Florida, cane cutting by hand has been the general practice since the industry was established. However, labor litigation events have caused the introduction of mechanical harvesting to the industry faster than generally anticipated. For example, 40 percent of the 90-91 crop was harvested mechanically. In the 91-92 crop it rose to 54 percent. For our last crop the figure reached almost 73 percent involving about 200 harvesters. Next year, we expect it to be in excess of 80 percent, weather permitting.

The combine harvester has been the machine of choice and has met considerable success. The change has resulted in easier harvesting operations. The time elapsed from burn to delivery at the mill has been reduced and fresher cane deliveries have been achieved.

However, some problems became apparent with increased machine harvested cane. Some of them are linked to the field while others concern the factory. For example, one concern is the high tonnage and recumbency of cane with the loose muck soils in Florida. These conditions are harmful to varieties with weak rooting systems. They tend to lodge heavily and sprawl. The result is stool removal. This leads to premature field replanting. It affects growers profits. So, breeders, agronomists and agricultural engineers are working together on this issue.

Another concern is that some growers are re-assessing the value of cultivation treatments following mechanical harvesting coupled with the high rainfall of the past crop. This combination requires increased care to correct unfavorable bulk densities in the soil caused by physical compaction. There is a marked decrease in rooting efficiency and drainage with increased soil density. These effects are caused by more field transportation passes per row in mechanical than in hand cut operations.

Finally, from the field point of view, the big question is what will happen when the Florida cane industry experiences a mid-to-late December freeze. In other words, how effective will the harvesters be in removing deteriorating tops after the third week of a freeze? No one knows the complete answer to this question yet.

In the factory, more elaborate milling equipment is being considered and/or installed. Inclusions of roots and adhering soil increases the load on the clarification station. The factories have attempted to counteract these problems by installing additional juice purification facilities to maintain a satisfactory quality of raw sugar in a "competitive market".

Other aspects of south Florida's agriculture blend usefully with sugar cane. For example, some growers are wisely alternating sugar cane with sweet corn or rice (or both) and vegetables. Growers use these farming strategies to optimize land use and total profits from the land. Incidentally, I should remind you that the Everglades Agricultural Area (EAA) vegetables supply much of the eastern United States during the winter.

Most of this farming practice takes place in fallow cane land. Recent sources show an average of 22,000 acres of rice planted annually. About 90-95 percent of this goes to fallow cane land. Farmers sow rice seed from late February to early May in laser leveled fields. What is more important is that this represents an environmentally friendly relationship. Yes, nutrient residues from the cane crop or spring sweet corn feed the rice so no additional fertilizer is needed for rice. For the grower, a side benefit is that rice will uptake a significant portion of any excess phosphorus that becomes available during the flooding operation. That is why rice is recommended by the Institute of Food and Agricultural Sciences (IFAS) of the University of Florida as a Best Management Practice (BMP).

Sweet corn, on the other hand, averages about 25,000 acres planted annually. About two-thirds is in fallow cane land and one-third in vegetable land. Sweet corn requires applications of fertilizer. However, such applications on sugar cane muck lands are generally regulated for phosphorus. The control over phosphorus is made while maintaining an economically viable farming operation for the sweet corn grower.

We have two reasons for controlling phosphorus. From the point of view of the grower, reduction of sucrose in the subsequent cane crop must be avoided. From the viewpoint of the environment, phosphorus inflow into the Everglades is blamed for changing its ecosystem.

The Florida sugar industry is suddenly facing a host of other issues. In two of them we are tied as domestic sugar producers with international and regional trade agreements. One is the General Agreement on Tariffs and Trade or GATT, also known as the Uruguay Round. What is GATT? Founded in 1947, it is a multilateral organization that sets rules of conduct for international trade. GATT's underlying philosophy is built around the concept that free markets work and that the goal of international trade policy should be to reduce trade barriers. This provides a safe and predictable international trading atmosphere. In return, it encourages industrial and commercial entities to have the trust to invest, create jobs and trade.

The present Uruguay Round of talks began in 1988. More than 100 member nations have met several times. At this moment, no agreement has been reached. In fact, the recent negotiating position taken by the U.S. compromised fairness and equity for U.S. farmers in exchange for greater trade liberalization. So, this "trading away of the domestic sugar industry for the sake of an agreement" pushed our domestic industry to the point of removing our support.

The other issue is the North American Free Trade Agreement (NAFTA) as it relates to sugar issues. What is NAFTA? In contrast with the international involvement of GATT, NAFTA is a regional trading block. NAFTA seeks to make all of the North American continent (U.S., Mexico and Canada) a free trade area in the near future. In other words, like GATT, NAFTA's goal is to reduce trade barriers and stimulate overall economic growth, but unlike GATT, NAFTA's confines are regional. Negotiators first met in June of 1991 in Toronto. At this moment, the sugar related issues in NAFTA are: (1) the size of Mexico's sugar quota in the U.S. market, (2) potential transhipment of raw sugar from Cuba or other countries into the U.S. via Mexico, (3) imports of sugar containing products from Mexico, and (4) the U.S. re-export program.

Presently, participants remain divided over the sugar issues as well as those regarding the automobile industry, energy, financial services, foreign investment, rules of origin, and trade dispute settlement mechanisms. Meetings continue, but before NAFTA becomes a reality, it has to be signed by the heads of state of the three countries and be ratified by their respective legislative bodies.

Closer to home, Florida growers are also facing demands from the state, the federal government and environmentalists. The latest round of action began in 1988. There is something wrong with the Everglades. This is probably not a surprise to you. You have no doubt read about it in the press, and seen various television news programs and documentaries. The farmers in the Everglades Agricultural Area agree there are problems with the Everglades ecosystem. Where we disagree with the government is on what the problems are and how they should be resolved. The federal government has charged that the phosphorus coming off the farms in the water runoff is the main culprit.

At this writing, to remove phosphorus, the government wants to implement a plan that will cripple farms, put people out of work and costs $400 million dollars. This plan calls for flooding 58 square miles of farmland to be used as phosphorus filter marshes. This is equivalent to flooding the entire area of the City of Miami plus 80 percent of Fort Lauderdale. If this does not clean the water, then more land will be flooded.

The current "Surface Water Improvement and Management Plan (Swim-Plan) calls for the above requirements.

At the time of this writing that was the status of things. Since then, a lot of intensive negotiations have taken place. And a lot is happening day by day.

In the mediations, a mix of private and public lands are involved which hopefully will greatly reduce the amount of farm land required for treatment of marshes.

Negotiations also continue to determine the industry's share of the cost for these projects.

Farmers have proposed alternatives that will give the same benefits at a fraction of the price and without costing jobs.

Now let me conclude with a few words about research and development. The main goal of the sugar industry remains that of lowering the unit cost of production. This is done by cost cutting, increasing yields per acre and improving factory efficiency.

These goals are met through research and development both in the field and in the factory.

From the field point of view in Florida, important lines of progress can be expected in the near future in these areas: (1) management of quality and quantity of water to reduce phosphorus agriculture runoff leaving the farms, (2) pre-harvest burning regulations to reduce nuisance complaints, (3) improvements in the establishment of a dense stand in successive plant cane, (4) extended use of hot water treated seed against ratoon stunting disease, (5) knowledge regarding the unpredictable sudden appearance of new and generally more virulent strains of the rust fungus, and (6) evolvement of cane yield measurements in research plots as the industry mechanizes harvesting.

Finally, from the factory point of view, continued attention is directed towards: (1) energy management, (2) improvements in the grinding rate and sucrose extraction, (3) juice purification and sugar processing, (4) analytical and chemical control, (5) automatic process control, and (6) by-product usage.

PEER REFEREED JOURNAL ARTICLES

SAMPLING OF SUGARCANE FIELDS FOR WIREWORMS (COLEOPTERA: ELATERIDAE)

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ABSTRACT

Wireworms are a major pest of sugarcane in Florida. However, growers do not have information about their populations within or across fields. Presently, growers apply soil insecticides routinely at planting. The objectives of this study were to sample for wireworm populations within ratoon fields of sugarcane, and to calculate the sample size for estimating field infestation. Wireworms were sampled in six second-ratoon sugarcane fields under three cropping systems (fallow, successive, and sugarcane following corn). Regression analysis indicated that populations were greater toward the centers of individual fields. Although there were no significant differences in wireworm population levels among cropping systems, there were observable trends that merit further study. Of the 4093 wireworms collected, 94% were *Melanotus* spp. A formula is proposed to determine the sample size needed to estimate means of normal populations to a given precision.

INTRODUCTION

Previous studies have identified wireworms as the most important pest of sugarcane in Florida (9,4). Wireworm damage to sugarcane has been described by Ingram et al. (9,10) and Gifford (4). Wireworms damage the underground portions of sugarcane plants. Larvae feed on the roots and buds, as well as the underground portion of the stem, often killing young, developing shoots. Most of the injury occurs at or near the point where the stem joins the seed piece or stubble. Injuries serve as entrance points for pathogens such as red rot. The most abundant and injurious wireworm species to sugarcane in Florida is Melanotus communis Gyll., a wireworm species found mainly in the muck soils (10,4,7). Eighteen fields sampled by Cherry (1) had a mean of 4.28 wireworms per meter of row, ranging from 1 to 15 wireworms per meter. Furthermore, he reported that wireworm populations were not significantly correlated with crop age.

Recently, the damage threshold with respect to stand reduction for M. communis during plant-cane germination was reported to be 2 wireworms/m of row (6); the threshold for ratoon crops is not known. Furthermore, Hall (8) reported that final tonnage of plant-cane stalks per ha was reduced 3.9 metric tons per wireworm per m of row. Ratoon cane tonnage was reduced by 1.9 metric tons per ha per wireworm per m of row during early cane growth.

In Florida, soil insecticides are routinely applied to sugarcane at planting as insurance against wireworm damage (8). Wireworm sampling has been extensively studied in other crops (3,14,12,13). Sampling information about wireworm populations in sugarcane is scarce.

The purposes of our study were to sample wireworm populations and determine their spatial distribution within fields of sugarcane, and to calculate sample size for estimating infestation levels.

MATERIALS AND METHODS

Cane fields were sampled for wireworms during February and March 1988 after the second-ratoon harvest in six 16.2 hectare fields of sugarcane cultivar CP 72-2086. Soil samples 61 cm long by 61 cm wide, and 25 cm deep were taken within the row. All plants and wireworms in each sample were counted as the soil was dug and the plants were inspected in the field. Wireworms were taken to the laboratory and sorted by genus. Sampled plants ranged from 15 to 30 cm high. Fields averaged 122 rows with 1.5 m between rows. A total of 65 samples were taken from each field. Thirteen samples spaced every 61 m were taken along rows number 2, 30, 60, 90, and 120. Of the six fields sampled, two were fallowed before planting sugarcane and were located along the same road separated by three fields. Two fields separated by a canal were planted with sugarcane after corn had been harvested. The two successive (sugarcane planted after a previous sugarcane field had been harvested in the same planting season) fields were also separated by a canal and were across the road from the other four fields.

Cropping system means were separated with a least significant difference (LSD) (P = 0.05) test by the RANGE procedure of MSTAT (11).

RESULTS AND DISCUSSION

The mean ± standard deviation over all six fields was 17.21 ± 9.91 wireworms per m of row. This results in an estimate of 112,932 wireworms per hectare. Number of wireworms per mm ranged from 1.64 to 54.13. Quartiles were Q1 = 9.84, Q2 = 14.76, and Q3 = 22.97. Regression analysis indicated that number of wireworms tended to be higher towards the center of the field and eastern rows of the fields (Fig. 1).

We used only those samples with mean numbers of at least 12 wireworms per sample to create Fig. 2. It highlights the distribution of wireworms in the field across and along the rows. Of the 4093 wireworms collected, 94% were *Melanotus*, 5% were *Conoderus*, and less than one percent were *Glyphonyx*.

Table 1 shows the mean number of wireworms per m of row did not differ significantly among cropping systems. However, we sampled only two fields from each cropping system. There are too few samples to determine if cropping systems affect wireworm population levels. Nevertheless, there are trends that would merit further studies, since data suggest that cropping system could influence wireworm populations.

Table 1. Mean number of wireworms per m of row per field and per cropping system.

Cropping system	Mean ± SD per meter per field	Mean per meter per cropping system
Cane after fallow	22.56 ± 8.65	18.27a
Cane after fallow	13.98 ± 6.59	
Cane after corn	17.79 ± 8.58	22.29a
Cane after corn	26.75 ± 10.84	
Cane after cane	12.32 ± 6.07	11.09a
Cane after cane	9.87 ± 5.68	
LSD		27.11

Means followed by the same letter are not significantly different at P = 0.05 using the unrestricted LSD

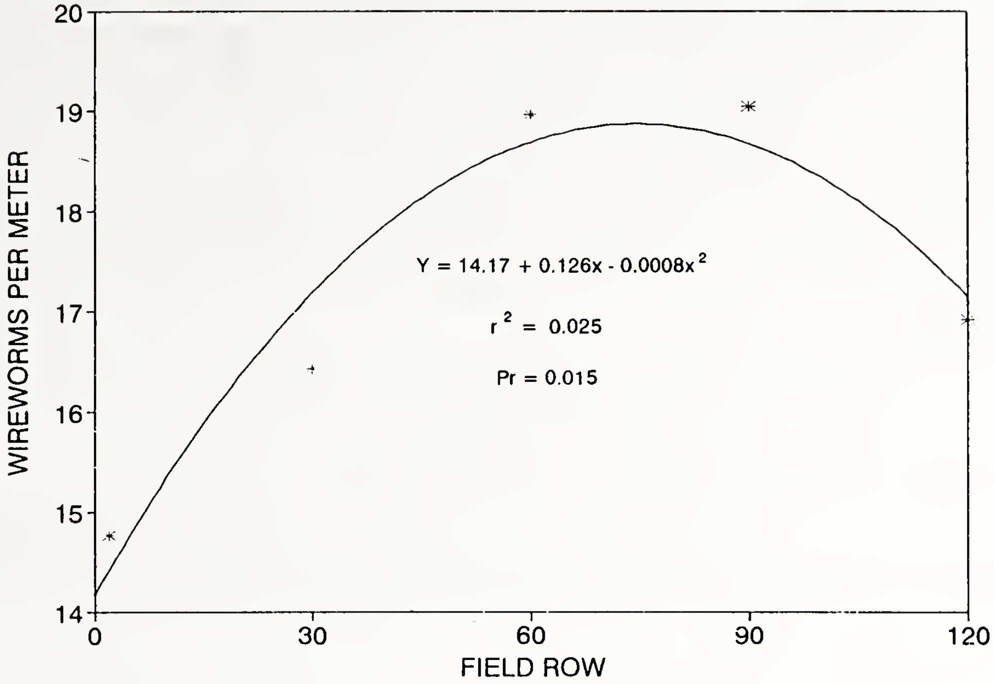

Figure 1. Quadratic regression of mean number of wireworms per meter of row across rows of six fields.

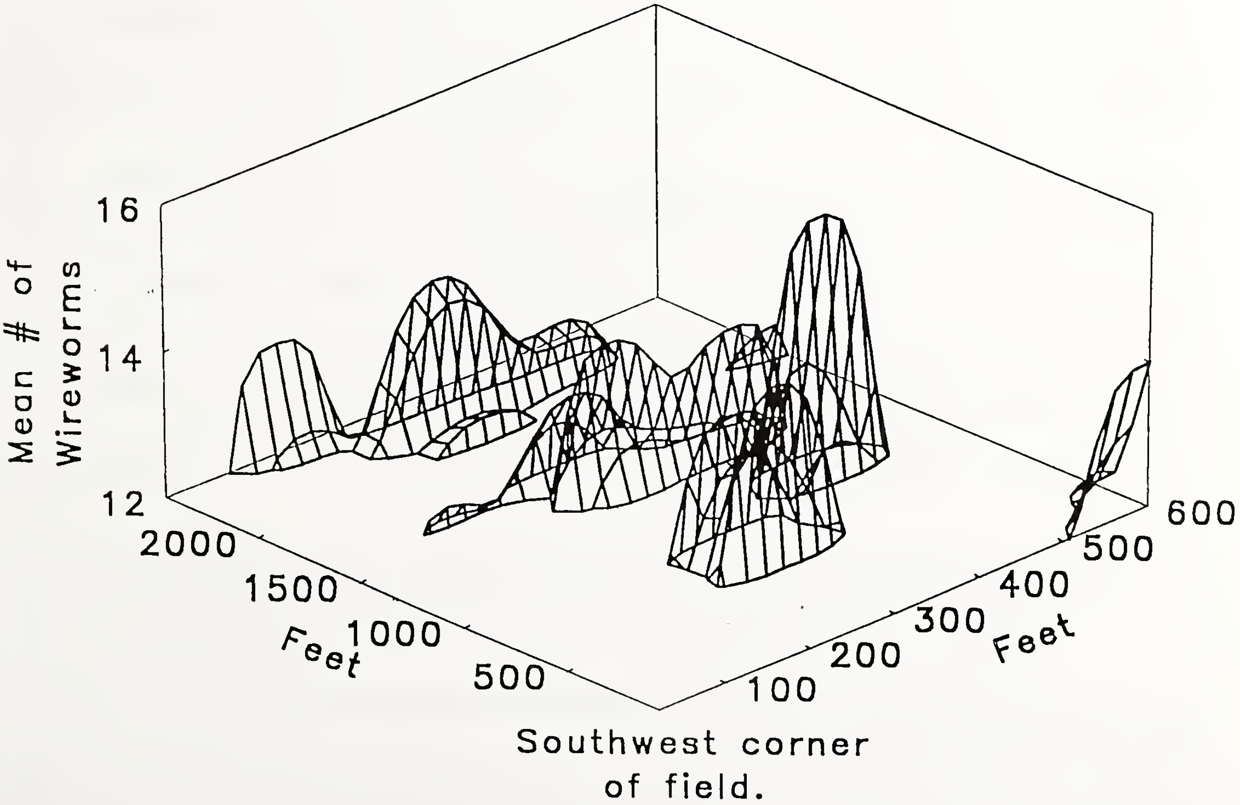

Figure 2. Mean wireworm distribution per sample (0.61 m of row), across, and along sugarcane rows, averaged over six fields.

To estimate sample size needed to obtain means of normal wireworm populations, we used a formula proposed by Chew (2). Briefly, $n = (z_\alpha \sigma/d)^2$, where n = sample size needed; z_α = two-sided (100α) % point of the standard normal distribution; σ = standard deviation of the population; and, d = specific precision (i.e., sample mean will not differ from the unknown population mean by more than d units). In using this formula, we assumed a normal population with unknown mean and known standard deviation. As an example, for field 6 data in Table 1, $\sigma = 5.67$. If we take $\alpha = 0.10$ then from tables of the standard normal distribution, the two-sided 10% point is $z_{.10} = 1.64$. Finally, if we choose the precision d to be 2 units, the above formula gives $n = [1.64\ (5.68)/2]^2 = 22$ samples. Thus, if we take 22 samples, we will have 90% confidence that the sample mean will not differ from the unknown population mean by more than ± 2 units. Since we took 65 samples, no additional samples are needed.

Hall (7) reported that significant stand reductions during early plant-cane growth may occur at infestation levels of fewer than three wireworms per m of row. Field 6 had the lowest level of wireworms in our study. Our levels were much higher than Hall's plant-cane. A 75% wireworm mortality in field 6 would be necessary to achieve Hall's threshold.

Additional information is needed on wireworm mortality from the time the ratoon crop is harvested to the time the new crop is to be planted. In Florida, 67% of the 1991 sugarcane hectarage was successively planted (5). Therefore, this information would be necessary if wireworm population estimates obtained from the sampling of ratoon crops is to be used as a basis to determine population levels at planting, and thus determine whether the application of pesticides is necessary.

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METHODS OF PRESERVING FEMALE TASSELS USED IN SUGARCANE CROSSES

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ABSTRACT

The objective of this group of experiments was to compare methods of preserving female tassels used in sugarcane crosses. The five treatments studied were: CP-acid solution, Brazil-acid solution, two variations of CP and Brazil solutions and air layers. Experiments were set up with males or polycrosses isolated in cubicles. Each cubicle contained female tassels from the same clone (grown under the same conditions) maintained in each of the different treatments to minimize differences except for method of tassel preservation. Males or polycrosses were used as replications because we had insufficient tassels to replicate under each male. The CP-acid solution was composed of 180 ppm of sulfur dioxide (SO_2) and 108 ppm phosphoric acid (H_3PO_4) dissolved in high quality water produced by treatment with a reverse osmosis (R/O) system and the solution was topped off with 8 l of the same solution 3 times per week. The Brazil-acid solution was composed of 170 ppm SO_2, 75 ppm H_3PO_4, 37 ppm sulfuric acid (H_3SO_4), and 37 ppm nitric acid (HNO_3) dissolved in R/O water at the time the cross was set up and was changed on alternate days. On days the Brazilian solution was not changed a grog solution (composed of about 30 ml of the 6% SO_2 solution) was added to each tub. The CP-acid solution and grog treatment consisted of the standard CP-acid solution when crosses were set up and then the grog solution applied on days when the solution was not topped off. The Brazil 1 week treatment was the standard Brazilian treatment at the time the crosses were set up and the grog solution was applied the next 6 days and the entire solution was changed on the 7th day. Air layered stalks were prepared by enclosing two nodes in wet sphagnum moss for root development. In experiment 1 (11 female and 4 male clones), experiment 2 (13 female and 6 male), experiment 3 (12 female and 5 male clones) there were no differences in seed set per gram of fuzz among acid treatments. There were differences among females and males in seed per gram of fuzz. In experiment 3, 4 clones with air layered tassels produced significantly higher seed set than any of the acid treatments. In experiment 4, conducted late in the crossing season pollen availability was significantly reduced, therefore, overall seed set was reduced. We have decided to utilize the Brazilian method to prepare the sulfurous acid solution used in our program because its cost is about one tenth of that of the commercially prepared sulfurous acid solution. At Canal Point, air layering female tassels is the most expensive way to maintain them; however it is still the best for seed set. In 1992-93, 1,684 air layered tassels produced an average of 418.8 seed/tassel while 2,533 acid maintained tassels produced an average of 236.6 seed/tassel.

INTRODUCTION

Among methods used in sugarcane hybridization was planting paired plots of desired parents to facilitate pollen transfer. Otherwise, it was necessary to cut the male tassels and take them to the female tassels. Male tassels were kept alive during pollination by simply placing cut ends in tap water and suspending the male tassels over the desired female tassels. However, the male tassels survived for only 1-2 days and then were replaced with fresh tassels (this work was being done between 4 and 6 a.m.) (5). Verret et al. (13) were the first to develop a weak acid solution (1 ml of 5% SO_2 diluted in 100 ml water) to preserve male tassels during the pollination process. Some of the male tassels remained alive long enough to set seed, hence, the start of the use of the Hawaiian weak acid solution to preserve both male and female cut tassels (1). Since then, there have been many additions and/or deletions of chemicals to the standard solution (2,8,11,12,14) and many different ways of handling the solutions (10,15).

An alternative to the use of the acid solution was the development of the "air layer" or "marcott" (4). Air layers are the most expensive way to maintain cut tassels because of the cost of supplies and mainly of the labor required to apply the air layer. We normally air layer four stalks/38 l pot, and are limited to that number because of the physical size of the air layers. At Canal Point, air layered tassels traditionally produce about twice as many seed (442 vs 206) as tassels preserved by the CP-acid solution (7). However, in recent years, we have had relatively low seed set in the new crossing house at Canal Point. It was suggested that changes in acid solution preparation and/or composition could improve seed set on acid maintained tassels. Treatments selected for these experiments were comparisons of the standard CP solution [similar to that reported by Manglesdorf (6)], the Brazilian acid system used by Copersucar (G. Rossi Machado, Jr. personal communication 1991), variation of the two systems that were easier to manage than the Brazilian system, and the standard air layer or marcott.

MATERIALS AND METHODS

Cultivars used to produce tassels included in these experiments were grown either in pots (38 l pots containing 2:1 muck to sand mixture) or field plots (muck). Air layers were applied to stalks 8-12 weeks prior to anthesis. Tassels were selected at random for inclusion in various treatments and were cut from field plots or pots shortly after the onset of anthesis. All crosses maintained in acid were kept in 19 l rubber tubs. For all acid treatments, at least one node was trimmed off the basal portion of the stalks at the time they were transferred from the pollination to the ripening area. An explanation of the five treatments follows. Treatment 1 was the CP-acid solution which is 180 ppm SO_2 and 108 ppm H_3PO_4. The solution was prepared and the tubs filled the day the cross was set up. Tubs were overflowed with approximately 8 l of the same solution three times a week after the initial set up. When tassels were moved from the pollination area to the ripening area, a new tub of acid was prepared. Afterwards, each tub was overflowed three times per week as in the pollination phase. Treatment 2 was Brazilian acid solution (G. Rossi Machado, Jr. personal communication 1991) which was composed of 170 ppm SO_2, 37 ppm H_3NO_4, 37 ppm, H_2SO_4, and 75 ppm H_3PO_4. The solution was changed completely on Mondays, Wednesdays, and Fridays and on all other days a grog solution (6% SO_2 solution) was added to bring the SO_2 concentration back up to 170 ppm (approximately 30 mls/tub). The grog solution was applied by using a hand held sprayer pumped up to about 140 to 170 k Pa and discharged for five seconds into the bottom of the tub. After pollination was completed and the female tassels were placed in the ripening area the solution in the tubs was emptied one time per week and the grog solution was added on other days in contrast to the pollination area where tubs were emptied and refilled three times per week. Treatment 3 was the CP-acid plus grog treatment which consisted of the standard CP-acid treatment plus the grog solution three times per week (on days when acid was not overflowed). Treatment 4 was the Brazil 1-week treatment which was the standard Brazilian acid solution at the time the cross was set up plus the grog solution three times per week. The solution was completely drained and refilled at the end of each week. This treatment was maintained during the seed ripening phase. Treatment 5 was air layers which were produced by enclosing two nodes in polyethylene and packing with wet sphagnum moss. Air layers were watered as needed until tassels were harvested. Air layered tassels were maintained during the crossing period by slicing the polyethylene bags and immersing the air layers in aerated water.

A complete set of treatments for a given female were maintained in the same cubical and were all exposed to the same pollen source. Females were maintained under male tassels for 12 to 15 days. All tassels were removed from under a given male on the same day. Tassels were then bagged individually and placed in the ripening area. Tassels were harvested from 30-35 days after the crosses were set up. They were dried for 48 hours at 30°C, removed from the drier and fuzz stripped. A one gram sample of fuzz was weighed and planted immediately in sterilized muck soil. Germination counts were made after 1 and 2 weeks and the higher germination count was used to estimate seed production. Data were analyzed across females, males and treatments using the GLM procedure in SAS.

Experiment 1 contained 11 female clones placed in crosses under 4 different males and contained three treatments: Brazilian acid, CP acid, and CP-acid + grog. Experiment 1 was set up 24 December 1992.

Experiment 2 contained 13 female clones, 6 male clones and the same three treatments as experiment 1 plus an air layer treatment. Experiment 2 was set up 29 December 1992.

Experiment 3 contained 12 female clones, 2 male clones and three polycrosses. Treatments were the same as experiment 2. Experiment 3 was set up 5 January 1993.

Experiment 4 contained 18 female clones, one male clone and three polycrosses. Treatments utilized in experiment 4 were the Brazilian and CP acid treatments and the Brazil 1 wk. treatment. Experiment 4 was set up 13 January 1993.

RESULTS AND DISCUSSION

The data for comparisons among females serve as a general guide for productivity of clones as seed parents. Comparisons among females may be biased as not all females were used under the same males. However, the female seed set data (Table 1) does show two important points. There were genetic differences among females in seed set with several significant differences among clones. CP 82-550 is a clone that consistently had poor seed set. Also, the later in the season the experiments were set-up the lower the average seed set. There were two primary explanations for this: the female tassels that develop later in the season were exposed to more cold weather [night temperatures below optimum (20°C) induce female sterility] Brett (4) and pollen availability was reduced later in the crossing season partially because of exposure to less than optimum temperatures and partly because the number of male tassels available to use in crosses was reduced.

The data on seed set with the different males and/or polycrosses (Table 2) show much the same variability that occurred among various female clones. Some clones, such as LCP 85-384, produced high seed set when used as male parents. Others, such as CP 70-321, produced very few viable seed when used as male parents. Generally, polycrosses at Canal Point have higher seed set than biparental crosses (unpublished data); however, this was not the case in experiments 3 and 4.

Seed set per gram of fuzz among acid treatments (Table 3) was not different in the first 3 experiments. In experiment 4, the Canal Point acid solution produced higher seed set than the Brazilian acid treatment. However, overall seed set in experiment 4 was so low that I have questioned these results. The air layered female tassels in experiment 2 had very low seed set, but experiment 3 was more representative of previous findings of the relationship in seed set between acid and air layer maintained tassels. For the past five crossing seasons, the relationship between seed set on acid maintained tassel was 49.3% of that on air layer maintained tassels. That figure compares favorably with an average of 46.6% obtained by Miller and Tai (7) for the ten years between 1979 and 1988.

Based on the results of these experiments, we will continue using our basic CP acid solution. However, we will purchase the SO_2 gas and bubble it through R/O water to form the sulfurous acid (H_2SO_3). Cost of the purchased 6% H_2SO_3 used in the 1992-93 crossing season was about $2,200 whereas the same amount and concentration of H_2SO_3 could have been prepared for about $210 using the Brazilian method of bubbling SO_2 gas through R/O water. In the future, we plan to make our own acid since there was no difference in seed set with the different acid solutions in the first three experiments.

Table 1. Female clones, number of tassels of each clone, and average seed set per gram of fuzz in experiments 1-4.

Female	N+	Seed set/g	Female	N+	Seed set/g
Experiment 1			Experiment 2		
CP 70-324	6	16.3 b*	CP 72-2086	3	24.7 cde
CP 70-1133	3	22.7 b	CP 73-1547	6	12.5 ef
CP 71-1240	12	22.4 b	CP 78-2114	5	61.6 a
CP 85-1382	6	32.0 b	CP 80-1557	8	2.1 f
CP 89-814	12	26.6 b	CP 82-550	3	3.3 f
CP 89-888	3	67.3 a	CP 84-1198	3	39.7 b
LCP 81-30	6	34.2 b	CP 84-1714	3	4.3 f
LCP 82-89	6	29.8 b	CP 86-1206	3	15.0 def
LCP 85-384	12	34.2 b	CP 86-1633	3	18.3 cdef
LHo 83-153	6	24.3 b	CP 88-1508	3	34.0 bc
US 90-23	6	17.2 b	CP 88-1561	6	31.7 bcd
			TCP 88-4007	3	4.0 f
Experiment 3			Experiment 4		
CP 70-324	4	16.8 bcd	CP 70-321	3	1.0 b
CP 72-2086	3	30.3 abc	CP 70-324	3	1.3 b
CP 79-348	3	13.3 cd	CP 72-2086	3	8.3 ab
CP 84-1714	4	54.8 a	CP 81-1254	3	28.3 a
CP 85-1382	3	14.0 cd	CP 82-550	3	1.0 b
CP 88-1762	9	14.7 cd	CP 84-1714	3	0.0 b
CP 88-718	6	3.8 cd	CP 85-845	3	4.7 ab
CP 88-739	3	8.0 cd	CP 86-936	3	5.7 ab
CP 89-814	3	43.3 ab	CP 87-1121	3	2.7 ab
CP 80-1743	3	2.0 d	CP 88-718	6	7.5 ab
LCP 82-89	6	16.0 bcd	CP 88-1762	8	14.5 ab
LCP 85-384	8	49.0 a	LCP 81-30	3	1.7 b
			LCP 82-89	3	17.7 ab
			LCP 85-384	3	13.3 ab
			LCP 86-426	3	0.7 b
			LCP 88-91	3	11.7 ab
			US 90-1091	3	17.7 ab
			US 90-17	3	0.3 b

+ N = Number of female tassels.

* Means followed by the same letter are not significantly different according to Duncan's Multiple range test 0.05 level.

Table 2. Males, number of female tassels under each male clone and average seed set for each male used in experiments 1-4.

Male	N+	Seed set/g	Male	N+	Seed set/g
Experiment 1			Experiment 2		
CP 70-330	18	41.7 a*	CP 70-321	11	4.8 d
CP 83-632	18	16.4 c	CP 72-2086	3	11.7 cd
TCP 83-3217	21	23.2 bc	CP 80-1827	9	24.6 bc
US 90-22	21	31.3 ab	CP 83-632	14	9.1 d
			CP 87-1274	11	26.6 ab
			LCP 85-384	9	38.9 a
Experiment 3			Experiment 4		
92 P 9	9	11.3 b	92 P 17	15	5.2 a
92 P 10	14	28.8 a	92 P 18	15	4.6 a
92 P 11	12	17.3 ab	92 P 19	19	12.9 a
CP 70-330	12	22.6 ab	US 90-22	12	8.4 a
CP 86-1967	10	32.3 a			

+ Number of female tassels.

* Means followed by the same letter are not significantly different according to Duncan's Multiple range test 0.05 level.

Table 3. Treatments, number of female tassels average seed set per gram of fuzz in each treatment in experiments 1-4.

Treatment	N+	Seed set/g	Treatment	N+	Seed set/g
Experiment 1			Experiment 2		
Brazil	26	30.7 a*	Brazil	18	23.3 a
Canal Point	26	27.9 a	Canal Point	17	17.5 a
Canal Point and Grog	26	25.7 a	Canal Point and Grog	18	19.0 a
Airlayer	--	---	Airlayer	4	5.0 b
Brazil 1 wk	--	---	Brazil 1 wk	--	---
Experiment 3			Experiment 4		
Brazil	17	13.6 b	Brazil	21	1.5 b
Canal Point	17	24.4 b	Canal Point	21	13.0 a
Canal Point and Grog	17	20.8 b	Canal Point and Grog	--	---
Airlayer	4	65.5 a	Airlayer	--	---
Brazil 1 wk	--	---	Brazil 1 wk	21	10.1 ab

+ Number of female tassels.

* Means followed by the same letter are not significantly different according to Duncan's multiple range test 0.05 level.

Table 4. Crossing year, number of female tassels maintained as acid and airlayers, average seed set per tassel and the ratio of seed set on acid to airlayer maintained tassels.

Year	Acid		Airlayers		Seed set/per tassel acid ÷ airlayered percent
	Number	Seed set /tassel	Number	Seed set /tassel	
92-93	2533	236.7	1684	417.8	56.6
91-92	2719	131.3	1710	320.3	41.0
90-91	3520	68.8	433	107.5	64.0
89-90	1588	103.4	913	294.2	35.1
88-89	1207	356.3	1534	683.0	52.1
Avg.	2313	179.7	1254	364.5	49.3

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RELATIVE ABUNDANCE OF WHITE GRUBS (COLEOPTERA: SCARABAEIDAE) IN FLORIDA SUGARCANE ON SAND AND MUCK SOILS

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ABSTRACT

Sugarcane fields in Florida on sand or organic (muck) soils were sampled to determine the abundance of white grub species (Coleoptera: Scarabaeidae). Adult flight activity was monitored with light traps and larval populations were estimated by soil samples. Both methods revealed similar patterns: more *Ligyrus subtropicus* (Blatchley) were found on muck, while more *Phyllophaga latifrons* (LeConte) and Anomala marginata (F.) were found on sand. *Cyclocephala parallela* Casey was more evenly distributed over soil types although they tended to favor sand. A practical implication of these results is that the most damaging species, *L. subtropicus*, is rare or absent on sand soils.

INTRODUCTION

In the earliest report of white grubs (Coleoptera: Scarabaeidae) as pests in Florida sugarcane, Ingram et al. (10) wrote of damaging infestations of *Phyllophaga latifrons* (LeConte) and *Cyclocephala immaculata* Olivier on sand. The latter was probably *C. parallela* Casey, the species reported by Gordon and Anderson (8). More recently, *Ligyrus subtropicus* (Blatchley) has been recognized as the grub pest of greatest economic importance in Florida sugarcane (Gordon and Anderson, 8), capable of reducing yields 39% at high infestation levels (Sosa, 16). The pest status of a fourth species commonly found in sugarcane, *Anomala marginata* (F.), has not been determined.

Gordon and Anderson (8) noted that *L. subtropicus* was most common on highly organic muck soils, while *C. parallela* Casey and *P. latifrons* predominated on sand-muck mixtures. Hall (9) provided information on the flight activity of scarab species in Florida sugarcane. However, these authors did not provide data on the abundance of white grub species with respect to soil type, nor did they report collecting from cane grown on sand soils. The relative abundance of white grubs is known to be correlated with soil texture in Australian sugarcane (Cherry and Allsopp, 6). Our objective was to compare the abundance of white grub species in muck and sand soils in Florida sugarcane.

MATERIALS AND METHODS

Light trap samples

General purpose blacklight traps with 15 W lamps were set adjacent to 6 commercial sugarcane fields in southern Florida. The fields were surrounded by large sugarcane acreage so that most adult

Scarabaeidae came from sugarcane fields. Three of the traps were located in fields on muck soil approximately 7.5 km ssw of South Bay and 13 km from the closest sand soil location (McCollum et al., 11). The other three fields were located on sand soil 5 km sw of Clewiston and about 5 km from muck soils (Belz et al., 2). One light trap was placed at the edge of each field for one night near the 15th of each month from August 1982 to August 1985. Captured insects were frozen for later identification. Total numbers collected on each soil type were analyzed for significant deviations from expected means using a Chi-square analysis (Sokal and Rohlf, 15).

Soil Samples

Thirty commercial sugarcane fields were sampled throughout the sugarcane growing region of southern Florida. Half the fields chosen were on muck soils (organic matter > 55%) and the other half on sand soils (organic matter < 12%). Fields were 5.2 to 16.2 ha in size and were sampled after harvest during December 1991 through March 1992. Sugarcane plants in the sampled fields were 2 or more years old (ratoon crops) and were selected because higher numbers of white grubs have been reported to occur in ratoon plantings compared to newly planted sugarcane fields (Cherry, 5).

Twenty-five soil samples were taken randomly within each field. Each sample was centered on a sugarcane stool and consisted of a 40x40x20 cm volume of soil and roots. Most larvae of *L. subtropicus* and *C. parallela* in sugarcane fields are known to be found within these confines (Cherry, 3). Each sample was visually searched in the field for 10 minutes. A preliminary study showed that an efficiency ≥ 95% for 3rd instars could be achieved with this method for each of the 4 grub species in both sand and muck soil. Grubs from each sample were preserved in 70% EtOH for later identification based on a key by Gordon and Anderson (8). Significant differences in mean numbers of grubs between soil types were identified with Student's t-Test (SAS Institute, 14).

A composite soil sample from each site was analyzed for organic matter and mineral nutrient content according to procedures outlined by Sanchez (13). Mean organic matter content of the muck soils sampled was 76.6% (Standard error of the mean (SE) = 2.95) while sand soils was 3.8% (S.E. = 0.84). Correlations between numbers of grub larvae and percent organic matter content were determined using the "PROC CORR" program which determined the correlation coefficients (R) and the probability that these were not equal to zero (SAS Institute, 14).

RESULTS

Adults

Adults of all four scarab species were collected in light traps located on both soil types (Table 1). Over 2.5 times more beetles were trapped on sand than on muck. The most abundant species was *C. parallela,* followed by *P. latifrons*, *A. marginata*, and finally *L. subtropicus*. However, *L. subtropicus* was more abundant on muck than all other species except for *C. parallela*.

Total numbers of each species caught on the two soil types deviated significantly from the expected 1:1 ratio by Chi-square analysis ($P < 0.001$). *L. subtropicus* adults were 3 to 4 times more abundant on muck than on sand. In contrast, many more *A. marginata* and *P. latifrons* were caught on sand than on muck. *C. parallela* was the most evenly distributed grub species over the two soil types.

Table 1. Total number of adult Scarabaeidae caught in Florida sugarcane fields on two soil types using three blacklight traps one night per month from August 1982 through August 1985.

Soil type	Species				
	L. subtropicus	*P. latifrons*	*C. parallela*	*A. marginata*	Total
Sand	36	633	750	366	1785
Muck	132	78	411	48	699
Total	168	711	1161	414	2454
X^2	109.7[a]	866.5	198.0	488.5	408.2[b]

[a] Chi-square for null hypothesis numbers of each species were equal between soil types (df = 1, *P* < 0.0001 for all).

[b] Chi-square for null hypothesis that adults were randomly distributed among soil types over all 4 species (df=3, *P* < 0.0001).

Seasonal flight activity was unimodal except for *A. marginata* which was bimodal (Table 2). Most adults of *L. subtropicus* were caught in June while numbers of the other species peaked in May. *A. marginata* had a second peak in August. These results agreed with a previously reported study carried out in a Florida sugarcane field characterized by soil of 76% organic matter (Hall, 9).

Table 2. Mean number per trap per night of 4 scarab species captured in six blacklight traps in Florida sugarcane fields during months of maximum catch.

Species	Flight Distribution	Months of Maximum Catch	Mean (SD) per Trap per Night
L. subtropicus	Unimodal	June	9.0 (4.1)
C. parallela	Unimodal	May	62.1(21.9)
P. latifrons	Unimodal	May	33.6(14.3)
A. marginata	Bimodal	May August	11.1 (6.3) 4.8 (3.6)

Larvae

Large, easily visible third instars of *L. subtropicus* and *C. parallela* were the predominant life stage observed and third instars of the two other species were also the most common stage. Cherry, (4) also observed predominantly 3rd instar grubs during these months. Abundance patterns of grubs followed patterns seen for adults. Mean numbers of larvae per sample differed significantly between the two soil types for 3 grub species, *L. subtropicus*., *P. latifrons* and *A. marginata* (Table 3). *P. latifrons* and *A. marginata* were more abundant on sand and their numbers were negatively correlated with percent organic matter content (R = -0.36 and -0.32 respectively, $P < 0.05$, N = 30). More *C. parallela* were also found on sand than muck although the difference and correlation with organic matter content were not significant. In contrast to the other three species, *L. subtropicus* was found only in muck soils. The lack of a significant correlation between the abundance of *L. subtropicus* and soil organic matter was probably due to the limited distribution of this species (33% of the muck fields sampled).

There were more grubs over all species on sand than on muck. *A. marginata* had the highest mean numbers in sand samples but were exceeded in maximum numbers by *P. latifrons* and *C. parallela* (Table 3). *A. marginata* occurred in more fields on sand than any other species. On muck, *C. parallela* was the most abundant species and occurred in the greatest number of fields, followed by *A. marginata* and *L. subtropicus*. However, the maximum number of *A marginata* in muck was the greatest of any species on this soil type.

Table 3. Mean(SE) and maximum number of 3rd instar grubs per field by soil type and percent of fields infested.

	Soil Type[a]					
	Sand			Muck		
Species	Mean(SE)	Max	%	Mean(SE)	Max	%
L. subtropicus^{*b}	0.0 (0.0)	0	0	1.8 (1.0)	12	23
P. latifrons**	7.8 (3.7)	58	38	0.1 (0.1)	1	1
C. parallela^{NS}	3.8 (2.5)	38	19	3.3 (1.2)	15	42
A. marginata**	8.9 (2.7)	27	43	2.7 (1.5)	20	34

[a] Fifteen fields for each soil type, 25 samples 40x40x20 cm from each field.
[b] Results of t-test for H_0 = no difference in abundance of larvae between soil types: * $P < 0.1$, ** $P < 0.05$, NS $P > 0.1$.

DISCUSSION

Our results show that the distributions of three of the four principle grub species found in Florida sugarcane are correlated with organic matter content of the soil. *A. marginata* and especially *P. latifrons* were more abundant on sand soils while *L. subtropicus* was absent from this soil type, occurring exclusively on muck. On the other hand, the abundance of *C. parallela* appeared to be less dependant on soil organic matter content although a trend toward more on sand soils was seen for both adults and larvae.

Biological factors responsible for the observed dependence of grub distribution on soil types remain unknown. However, soil parameters including soil texture are reported to affect egg and larval survival (Gaylor & Frankie, 7) and oviposition (Potter (12), Allsopp et al., 1) in other species of Scarabaeidae. Preliminary results indicate a preference by *L. subtropicus* females to oviposit in muck versus sand soil (R. Cherry, unpublished data).

One practical implication of our results is that growers of Florida sugarcane on sand need be less concerned with the threat of grub damage than for cane grown on muck. This is because *L. subtropicus,* the most economically important grub species, is wholly or largely absent on sand soils. On the other hand, the historical occurrence of damaging *C. parallela* and *P. latifrons* populations on sand was substantiated by our finding that large numbers of these two species are occasionally found in this soil type.

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YIELD INCREASES NEEDED TO JUSTIFY SUBSURFACE DRAINAGE IN SUGARCANE FIELDS

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ABSTRACT

A study was conducted to determine the cost of installing subsurface drainage in Louisiana and to determine if the increase in sugar yields attributed to subsurface drainage was sufficient to justify installation costs. Drain system costs ranged from $170.00/A for systems with drains spaced 160 feet with a gravity drain outlet and no interest payments to $2158.00/A for systems with drains spaced 18 feet with a pumped outlet and 10 percent loan interest. Sugar yield increases needed to pay for these drainage systems, assuming the land owner/grower's share of the market price of sugar is $0.132/lb, ranged from 161 lb/A for systems with 160 ft drain spacing to 2044 lb/A for systems with 18 ft drain spacing. The cost of installing subsurface drainage systems, including payments with 10 percent interest for 10 years, was justified by increased sugar yields for Commerce (*fine-silty, mixed, nonacid, thermic Aeric Fluvaquents*) silt loam with 80 ft drain spacing and Jeanerette (*fine-silty, mixed, thermic Udollic Ochraqualfs*) silty clay loam with 90 ft and 135 ft drain spacings. Sugar yield increases resulting from subsurface drainage on Baldwin (*fine, montmorillonitic, thermic Vertic Ochraqualfs*) silty clay and Sharkey (*very-fine, montmorillonitic, nonacid, thermic Vertic Haploquepts*) clay were not sufficient to justify the cost of installing subsurface drains. The value of enhanced trafficability benefits, due to subsurface drainage, was not included in this study.

INTRODUCTION

Annual rainfall during the past 30 years has ranged from 40 to 90 inches in the sugarcane growing area of Louisiana with yearly averages of 55 inches in the northern part of the sugar belt and 65 inches in the south (16). Annual evapotranspiration (ET) is only about 42 inches. However, average annual rainfall exceeds ET by 13 to 23 inches and may exceed ET by as much as 48 inches in high rainfall years. The excess rainfall either runs off the land or infiltrates the soil and causes the water table to rise. High fluctuating water tables can inhibit crop growth, reduce yield, reduce stubble longevity, and prevent timely field operations.

Louisiana sugarcane fields are generally crown-shaped with lateral drains 1.5 to 3 feet deep spaced 150 to 250 feet apart (14, 15). Quarter drains are constructed from low places in each field to the lateral drains with the number of quarter drains depending on the number of low places that require drainage.

Little effort is devoted to draining the soil profile. Lateral surface drains provide some soil profile drainage but their effectiveness is limited because of shallow depth and wide spacing. Research in Louisiana has shown that subsurface drainage lowers the water table, particularly in silt loam and silty clay loam soils (6, 8, and 9). By lowering the water table, yields and stubble longevity were increased and the delay in entering fields after rains was shortened.

Sugarcane farmers have shown an interest in subsurface drainage but are reluctant to install drains. The primary reasons for this reluctancy are unfamiliarity with subsurface drainage in general, unfamiliarity with the many variables involved in determining costs, and the uncertainty as to whether yield increases caused by subsurface drainage are sufficient to justify the installation cost. The purposes of this paper were to 1) determine the cost of subsurface drainage for various drain spacings with and without a pumped outlet; 2) determine the increases in sugar yield needed to justify the cost of subsurface drain installation, and 3) determine if increased sugar yields resulting from subsurface drainage were sufficient to justify drain installation.

MATERIALS AND METHODS

Subsurface drainage sites

Subsurface drainage experiments with sugarcane were initiated in small plots in 1966 and in field plots in 1972 (4, 5). Since 1972, sugarcane responses to subsurface drains spaced 18, 20, 36, 40, 45, 60, 80, 90, 120, 135, and 160 feet apart have been evaluated at various field locations in Louisiana.

The first experiment was located on the Crescent farm in Terrebonne Parish. Subsurface drains were installed with a wheel-type trencher in 1972 with drains spaced 20, 40, and 80 feet, all without filters, on Mhoon (*Fine-silty, mixed, nonacid, thermic, Typic, Fluvaquents*) silty clay loam soil. Sugarcane (cultivar CP 52-68) was planted in the fall of 1973 and three crops were harvested (2).

In 1976, subsurface drains were installed on the Graugnard farm in St. James Parish on Commerce (*fine-silty, mixed, nonacid, thermic Aeric Fluvaquents*) silt loam. The ARS drain tube plow equipped with a laser grade control system (12) was used to install the drains 80, 120, and 160 feet apart (6, 8). All drains were installed without filters. Yields from 11 sugarcane crops were measured from 1977 to 1990. Sugarcane cultivar CP 48-103 was planted in 1976 for the first cropping cycle: CP 70-321 was planted in 1981 and 1986 for the other two cropping cycles.

Subsurface drains were installed at the Louisiana Agricultural Experiment Station in Iberville Parish on Sharkey (*very-fine, montmorillonitic, nonacid, thermic Vertic Haploquepts*) clay soil in 1977. The ARS drain tube plow was used to install drains 18 and 36 feet apart. All drains were installed without filters. Yields from four crops of sugarcane (cultivar CP 65-357) were measured from 1978 to 1981.

Subsurface drains were installed on the Patout farm in Iberia Parish in 1978 on Jeanerette (*fine-silty, mixed, thermic Udollic Ochraqualfs*) silty clay loam (9). The ARS drain tube plow was used to install drains 45, 90, and 135 feet apart. All drains were installed with filters. Sugar yields from nine crops were measured from 1980 to 1990. Sugarcane cultivar NCo-310 was planted in 1979 for the first cropping cycle. CP 70-321 was planted in 1983 and 1988 for the other two cropping cycles.

Subsurface drains were installed on the Sterling farm in St. Mary Parish in 1978 on Baldwin (*fine, montmorillonitic, thermic Vertic Ochraqualfs*) silty clay. The ARS drain tube plow was used to install drains 45 and 90 feet apart. All drains were installed with filters initially. After yields were measured from two crops in 1979 and 1980, the drains were replaced in 1981 with drains that had no filters. A chain-type trencher was used to install the drains in 1981. Sugar yields from seven more crops were measured from 1982 to 1990. Sugarcane cultivar CP 65-357 was planted in 1978 for the first cropping cycle. CP 70-321 was planted in 1981 and 1984 for the second and third cropping cycles, and CP 70-330 was planted in 1988 for the fourth cropping cycle.

Subsurface drains were installed on the USDA Sugarcane Laboratory's farm in Terrebonne Parish on Commerce (*fine-silty, mixed, nonacid, thermic Aeric Fluvaquents*) silt loam (13, 7). A chain-type trencher was used to install drains spaced 60 feet apart. All drains were installed with filters. Sugar yields were measured from three crops (cultivar CP 65-357) beginning in 1980.

In each field experiment, a laser system was used on the trencher or plow to control the slope of the drain tubes which was parallel to the soil surface. Drain slopes varied from approximately 0.2 percent to 0.3 percent among locations. Drain depth varied from 3 feet to 4 feet among locations.

The cultivars planted for these experiments were selected by the respective sugarcane growers. In general, the cultivars were selected from a list of varieties recommended by the LSU Extension Service personnel (11). Before varieties are placed on the recommended list they are tested for responses to light-textured and heavy-textured soils but not for responses to subsurface drainage.

Drain Material Costs

The materials required to provide subsurface drainage for fields 1000 feet long were determined and converted to cost per acre. The materials required for each drain line were: 1000 feet of 4-inch drain tubing, one 4-inch by 6-inch tee adapter, three drain tube couplers, one end cap, and enough main drain line to reach the adjacent drain line or the drain outlet. The area served by one drain was determined by multiplying drain length and drain spacing. The number of drains required in each field was determined from the total field area divided by the area served by one drain line.

The cost of subsurface drainage materials used in this report was based upon 1993 prices quoted by a representative from a plastic drain tubing manufacturing company. The costs of drain materials were: $0.29/foot for 4-inch perforated, corrugated, plastic drain tubes wrapped with filter fabric ($0.22/foot for drain tube without a filter); $4.80 each for 4-inch by 6-inch tee adapter; $0.70 each for 4-inch drain tube coupler; $0.80 each for 4-inch end cap and $0.45/ft for 6-inch main non-perforated tubing with no filter. Thus, the cost of materials for each 1000 feet of drain line without a filter would be $227.70 ($220.00 for the tubing and $7.70 for the fittings). Materials for each drain line with a filter would cost $297.70 ($290.00 for the tubing and $7.70 for the fittings). In both cases, connecting the main line, the length of which equals the drain spacing, is an additional cost.

Example calculations for determining the cost of materials for a drain spacing of 90 feet are as follows: The area served by one drain line was determined by multiplying the drain spacing (90 ft) and drain length (1000 ft) = 90,000 ft^2 or 2.07 acres. The cost of a drain line without a filter (from previous paragraph) is $227.70 and main line costs $40.50 (90 feet at $0.45/ft). Total material cost is ($227.70 + $40.50)/2.07 A = $130/A. For drains with the same spacing but with a filter on the drain, the total material cost is ($297.70 + $40.50)/2.07 = $164/A.

Sump cost

Sumps with float-activated electric pumps were used as drain outlets in each experiment. Sumps, however, may not be needed in every case. Many fields in Louisiana have surface drainage ditches that are more than 4 feet deep and could be used as subsurface drain outlets. Therefore, the costs of installing subsurface drainage systems both with and without sumps were determined. The cost of a sump and pump was estimated at $2000. This cost was based on 1992 charges for sumps provided by a metal fabricating contractor in Baton Rouge. One sump should serve at least 20 acres, thus the cost per acre for a sump was estimated at $100.

Sumps used at the various subsurface drainage sites were usually 4 by 4 by 10 feet deep. Many were made in farm shops from scrap materials. One sump, at the Iberia site, was an old 5 ft diameter boiler tube 10-feet long. Sumps at the USDA site in Terrebonne Parish were 5 ft diameter legs from off-shore oil drilling platforms. Metal plates were welded on the bottom of each sump. The plates extended out from the sumps to form a one ft lip around the perimeter. After each sump was in place, approximately 1.5 $yards^3$ of concrete were poured onto the lip to prevent the sump from floating. Metal pipes through which the plastic perforated drain tubes entered the sumps were welded into the sides of the sumps at a height of approximately 2.5 feet above the bottom. The metal pipes extended outward from the sumps approximately 10 feet to provide support for the drain tubes where the area around the sump was backfilled and to avoid a potential reversal in grade of the drain tubes should the backfill settle. The cost of providing power to the sumps was not included in the total cost of subsurface drainage systems. Electric companies usually provide power to the sites without charge unless the sites are a great distance from their main power line. The monthly cost of electricity to operate the sump pump varies, depending upon the amount of water pumped. In most cases approximately $1/A/month would be sufficient to cover the operating cost of the pump (10).

Drain installation costs

Installation involves opening trenches, installing lateral drains, connecting lateral drains to main drains, and backfilling the trenches. The cost of installing subsurface drains was difficult to determine because no subsurface drainage contractors routinely operate or conduct business in the lower Mississippi Valley. Installation charges in the mid-western United States vary from less than $0.15/ft to more than $0.50/ft. Using the $0.15/ft to $0.50/ft range as a guide, we estimated the cost of drain installation at $0.28/ft.

Amortization Period and Payment Estimates

Drainage systems installed by the authors in East Baton Rouge Parish in 1975 are functioning as well today as they did when installed (1). This means that the life of drainage systems in Louisiana is at least 19 years. Amortization periods frequently selected for investment-type practices, such as subsurface drainage, is the life of the system. However, if lending institutions provide financing for a practice, an amortization period less than the life of a practice is usually required. For this study, we chose 10 years as the amortization period and determined payback periods for cases with and without an interest rate of 10 percent. For sugarcane, the value of the average yield increase in eight crops during a 10-year period must be sufficient to pay for a drainage system because only three crops are produced in a four-year period. The fourth year is required to destroy the sugarcane stubble, fallow the land for several months, and replant for the next three crops.

Determining actual sugar yield increases attributed to subsurface drainage

At each of the subsurface drainage sites an adjacent area of the same soil type that had no subsurface drains was used for comparisons. Differences in sugar yields between the two areas were attributed to subsurface drainage because the areas were treated identically. The value of the increase in sugar yields, because of subsurface drainage, was determined by multiplying the yield increase in lbs/A by $0.132/lb, the price the grower who owns his land receives for sugar after milling costs have been paid. The value of the measured yield increase was compared to the calculated yield increases needed to justify the cost of installing subsurface drainage. If the value of the actual yield increase exceeded the calculated increase needed to pay for the drain installation, then installation of subsurface drainage was justified.

Statistics

Except for the experiment at the USDA site in Terrebonne Parish, the field experiments were not replicated. They were, however, repeated for several years. Therefore, tests for statistical differences between drained and non-drained treatments were made using the paired t-test with years as replicates.

RESULTS AND DISCUSSION

Subsurface drainage system installation costs

The costs to install subsurface drainage systems for drains spaced from 18 to 160 feet are shown in Table 1. These drain spacings were those used in field tests in south Louisiana during 1974 through 1990. Some drains were installed with filters and some were installed without filters, as noted in Table 1. Total costs ranged from $170.00/A for a drainage system with drains spaced 160 feet, no sump, and no interest payments to $2158.00/A for a drainage system with drains spaced 18 feet, a sump, and 10 percent interest payments for 10 years (Table 1).

Yield increases needed to pay for subsurface drainage system

For each $100.00/A spent to install subsurface drainage systems an increase of 758 lbs/A of sugar is needed for repayment by a grower who owns his land, assuming the grower receives a net $0.132/lb for sugar. In a 10-year repayment period, eight crops of sugarcane are usually grown. Hence, an average increase of 94.75 lb/A of sugar is needed for each harvest to justify subsurface drain installation.

Drainage systems without sumps and without interest payments were the least expensive while systems with sumps and with interest payments were the most expensive (Table 1). The needed yield increases ranged from 161 lb/A/crop for the 160 ft spacing with no sump and no interest payments to 2044 lb/A/crop for 18 ft spacing with a sump and 10 percent interest payments (Table 2).

Table 1. Drain installation costs both with and without sumps and interest charges.

Drain space	Filter	Soil texture[1]	Location	Drain Cost[2]		Total Cost			
						no interest		interest	
						-- sump --		-- sump --	
				tube	install	no	yes	no	yes
ft	y/n		Parish	$/A	$/A	$/A	$/A	$/A	$/A
18	no	c	Iberville	571	690	1261	1361	1999	2158
20	no	sicl	Terrebonne	516	622	1138	1238	1805	1963
36	no	c	Iberville	296	351	646	746	1025	1184
40	no	sicl	Terrebonne	268	317	585	685	928	1086
45	no	sic	St. Mary	240	283	523	623	830	989
45	yes	sicl	Iberia	308	283	591	691	938	1096
60	yes	sil	Terrebonne	236	215	451	551	716	874
80	no	sil	St. James	144	164	308	408	489	648
80	no	sicl	Terrebonne	144	164	308	408	489	648
90	no	sic	St. Mary	130	147	278	378	440	599
90	yes	sicl	Iberia	164	147	312	412	494	653
120	no	sil	St. James	103	114	216	316	343	502
135	no	sicl	Iberia	116	102	218	318	346	505
160	no	sil	St. James	82	88	170	270	270	429

[1] Abbreviations used for soil texture are: c = clay; sic = silty clay; sil = silt loam; and sicl = silty clay loam.

[2] Drain tube cost includes drain tubing, connectors, end-caps, and tees. Drain installation cost includes opening the trench on grade, laying drain tubes in the trench, making connections, and back-filling trench.

The increase in yields needed to justify the cost of installing closely spaced drains where interest payments are required is almost prohibitive with the present crop varieties and cropping practices. For example, to justify installing drains 18 feet apart requires an increase in sugar yield of 1893 lb/A/crop for drainage systems with no sump and 2044 lb/A/crop for drainage systems with sumps (Table 2). Consequently, the yields would have to be 34 and 36 percent greater than the Louisiana state average yield of 5647 lb/A. Drains spaced less than 36 feet would probably be on clay soil, where increasing average sugar yields by 30 percent is unlikely.

Yield increases due to subsurface drainage

The measured crop yield increases, attributed to subsurface drainage, are shown in the last column of Table 2. The highest sugar yield increases were obtained from the Jeanerette silty clay loam soil in Iberia Parish. Areas of Jeanerette soil, with drains spaced 45, 90, and 135 feet, yielded significantly more sugar per acre than did the non-drained area. In St. James Parish, only the area with drains spaced 80 feet apart yielded significantly more than the non-drained area on Commerce silt loam. In Terrebonne Parish, the area with drains spaced 60 feet apart on Commerce silt loam yielded significantly more sugar per acre than did the non-drained area.

Table 2. Sugar yield increases needed to justify subsurface drain installation costs and the actual yield increases attributed to subsurface drainage.

			--- Total drain cost ---				Yield increases needed to justify drain costs [2]				
			no interest		interest		no interest		interest		Actual
Drain	Soil		-- sump --		-- sump --		-- sump --		-- sump --		yield in-
Space	texture[1]	Location	no	yes	no	yes	no	yes	no	yes	crease[3]
ft		Parish	$/A	$/A	$/A	$/A	lb/A	lb/A	lb/A	lb/A	lb/A
18	c	Iberville	1261	1361	1999	2158	1194	1288	1893	2044	109
20	sicl	Terrebonne	1138	1238	1805	1963	1077	1172	1709	1859	178
36	c	Iberville	646	746	1025	1184	612	707	971	1121	575
40	sicl	Terrebonne	585	685	928	1086	553	649	878	1029	449
45	sic	St. Mary	523	623	830	989	496	590	786	936	365
45	sicl	Iberia	591	691	938	1096	**560**	**655**	**888**	1038	938a
60	sil	Terrebonne	451	551	716	874	**427**	**522**	678	828	535a
80	sil	St. James	308	408	489	648	**292**	**387**	**463**	**613**	706a
80	sicl	Terrebonne	308	408	489	648	292	387	463	613	230
90	sic	St. Mary	278	378	440	599	263	358	417	567	0
90	sicl	Iberia	312	412	494	653	**295**	**390**	**468**	**618**	928a
120	sil	St. James	216	316	343	502	**205**	**300**	**325**	475	376
135	sicl	Iberia	218	318	346	505	**207**	**302**	**328**	**478**	713a
160	sil	St. James	170	270	270	429	**161**	**256**	**256**	406	264

[1] Abbreviations used for soil texture are: c = clay; sic = silty clay; sil = silt loam; and sicl = silty clay loam.

[2] The needed yield increases, shown in bold type and underlined, were justified by the actual sugar yield increases shown in the last column.

[3] The letter "a" in the actual-yield-increase column indicates those yields that were increased significantly by subsurface drainage (probability at the 95 percent level).

Yield increases measured in the field were then compared to yield increases needed to justify subsurface drain installation costs. The needed yield increases that were exceeded by the measured yields are indicated by bold type and underlining in Table 2. Increases in sugar yield on Jeanerette silty clay loam in Iberia Parish with drains spaced 90 and 135 feet and on Commerce silt loam in St. James Parish with drains spaced 80 feet justified the cost of installing drainage systems in all four situations, even where interest payments are made. The yield increase from the area with drains spaced 60 feet in Commerce silt loam in Terrebonne Parish justified installing the drainage system for the two situations (sump and no sump) where no interest payments were required. The experiment with Commerce soil in Terrebonne Parish lasted for only 3 years (one cycle). The drain spacing of 60 feet may be closer than is needed for Commerce silt loam soil. This soil type is the same as that in the experiment at the St. James Parish site where drains spaced 80 feet were effective in lowering the water table and increasing sugar yields.

Sugar yield increases were not sufficient to justify subsurface drainage of Baldwin silty clay in St. Mary Parish and Sharkey clay soil in Iberville Parish (Table 2). The value of enhanced trafficability was not included in this study but it could be a major benefit of subsurface drainage on a clay soil. In the sub-tropical climate of south Louisiana where the interval between rainfall events is small, being able to conduct machinery operations in fields at the proper time may mean the difference between a good crop and a poor one. However, estimating the value of trafficability is difficult and was not attempted in this study.

The experiment on Mhoon silt loam soil in Terrebonne parish resulted in data which may be misleading. Unusually dry weather conditions during 2 years of the 3-year study in Terrebonne parish prevented the collection of representative data. In 1974, annual rainfall was only 41.7 inches, which was 23.6 inches below normal. In 1976, annual rainfall was 45.7 inches which was 19.7 inches below normal. Extremely low rainfall, like that in 1974 and 1976, is rare. In the past 42 years, annual rainfall at Houma, Louisiana was less than 47 inches only twice. In 1975, sugarcane responded in a very positive manner to subsurface drainage where annual rainfall was 71.6 inches, and yields from the subsurface drained areas were 20 percent greater than those from the non-drained area (3). Mhoon soil is similar to Commerce except the Mhoon has a very distinct 12-inch layer of silt located approximately 4 feet below the soil surface whereas layers of silt in the Commerce soil are not always connected and their depths vary. The distinct silt layer in Mhoon silty clay loam soil enhances subsurface drainage so that it drains more readily than Commerce soil. If subsurface drainage is justified for Commerce soil by increased sugar yields, it also may be justified for Mhoon soil.

CONCLUSIONS

The cost of installing subsurface drainage systems, including payments at 10 percent interest for 10 years, was justified by increased sugar yields for Commerce (*fine-silty, mixed, nonacid, thermic Aeric Fluvaquents)* silt loam with 80 ft drain spacing and for Jeanerette (*fine-silty, mixed, thermic Udollic Ochraqualfs*) silty clay loam soil with 90- and 135 ft drain spacings. The cost of installing subsurface drains was also justified by increased sugar yields for Commerce silt loam soil with 60 ft drain spacing if interest payments were not included. Crop yield increases resulting from subsurface drainage of Baldwin (*fine, montmorillonitic, thermic Vertic Ochraqualfs*) silty clay and Sharkey (*very-fine, montmorillonitic, nonacid, thermic Vertic Haploquepts*) clay were not sufficient to justify the cost of installing subsurface drainage systems.

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ANTHERAL TRANSFORMATION INTO STIGMA IN INTERSPECIFIC AND INTERGENERIC HYBRIDS OF *SACCHARUM*

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ABSTRACT

Several F_1 hybrids from *S. spontaneum* crossed with commercial cultivars, *S. officinarum*, and related grasses (*Erianthus* and *Miscanthus*), and their BC_1 and F_2 plants from interspecific and intergeneric hybridizations were used to examine the transformation of anthers into stigmas in their flowers. The anther- or anther-primordium-transformed stigmas could be morphologically classified into antheral form (stigma with an incomplete anther at base) and non-antheral form (stigma with a carpel at base rather than anther). Multiple stigmas, which could number 12 or more, often developed from a single anther primordium site within one flower in some plants. Antheral transformation may be associated with the cytoplasm of female parents. Besides the antheral transformation, other variations of floral organs also were found. Those variations would influence pollination and seed set and could be an obstacle to conducting interspecific and intergeneric hybridizations for broadening the genetic base of sugarcane.

INTRODUCTION

Sugarcane is a monoecious plant in which the flower has three stamens and one pistil (1,2). The pistil has one ovary with two feathered stigmas. All other species in the genus *Saccharum* have three stigmas (1). In sugarcane subtribe (*Saccharineae*), only *Imperata* Cyr., *Miscanthus* sect. Diandra Keng, and *Erianthus* Michx. (New World species) have less than three stigmas (2). Pistil and anther abnormalities, however, were observed in hybrids derived from crosses between *S. spontaneum* and commercial cultivars (4,5). The abnormalities, which include stigmatic papilae at the anther tip and one or all anthers being transformed into pistils, were observed among some progenies obtained from interspecific and intergeneric hybrids in the basic sugarcane germplasm utilization program at Canal Point, Florida. The objective of this study was to examine the transformation of anthers into stigmas in flowers of some interspecific and intergeneric hybrids and their F_2 and BC_1 progenies in sugarcane and related genera.

MATERIALS AND METHODS

Interspecific and intergeneric hybrids and their F_2, BC_1 and parental clones were used for this study during the 1991/92 and 1993/94 flowering seasons (Table 1). All clones were grown in the field and flowers were collected and examined for the antheral transformation. Tassels of some selected F_1 hybrids, BC_1 and checks were cut from the field and bagged separately with brown paper bags and then kept in the crossing house until seed were mature. Two clones with normal anthers and stigmas (US 88-1004 and US 90-1074) were used as checks for the measurement of seed set. Seedlings obtained from one gram of fuzz per cross were used to estimate the number of viable seeds produced.

RESULTS AND DISCUSSION

Anther transformations varied among F_1's and among their F_2 and BC_1 progenies as observed in the number of stigmas (Tables 2 and 3). Seven plants, N25-1, N26-1, 2, 3, 5 and 6, and X81-27-4, showed 1 or 2 of the three anthers transformed into stigmas, whereas US 88-1002, US 88-1003, US 88-1029, X89-216-4 and SM 8136-10 showed 2 to 3 anthers transformed into stigmas (Fig. 1 E-G and Fig. 2 B-C). Stigma development at the tips of anthers was also observed (Fig. 1 B-D).

Table 1. Parents, interspecific and intergeneric hybrids and their progeny used for the study of antheral transformation in the *Saccharum* complex.

Clone/Cross	Gen.	Parents
S. spontaneum - sugarcane hybrids and their backcross progenies:		
US 88-1001	F_1	*S. spontaneum* 'Uganda' X CP 70-1133
US 88-1002	F_1	*S. spontaneum* 'Uganda' X CP 70-1133
US 88-1003	F_1	*S. spontaneum* 'Uganda' X CP 70-1133
N6	F_1	*S. spontaneum* 'IJ 76-315' X *S. spontaneum* 'IND 81-138'
N25	F_1	*S. spontaneum* 'PIN 84-1' X *S. officinarum* 'Muntok Java'
N26	F_1	*S. spontaneum* 'PIN 84-1' X CP 70-1133
N27	F_1	*S. officinarum* 'Green German' X *S. spontaneum* 'IND 81-146'
X793	F_1	CP 65-357 X *S. spontaneum*'Coimbatore'
X89-41	BC_1	US 88-1003 X CP 85-1845
X89-216	BC_1	US 88-1003 X CP 84-222
X89-279	BC_1	US 88-1016† X CP 85-1845
Intergeneric hybrids and their backcross progenies:		
US 84-1030	F_1	*S. spontaneum* 'Uganda' X *Erianthus proceus* 'SES 336'
US 88-1029	F_2	US 84-1030 Self
X81-27	F_1	*S. spontaneum* 'IS 76-201' X *E. arundinaceum* 'IK 76-99'
X89-280	BC_1	US 88-1024† X CP 86-901
SM 8136‡	BC_1	SM 79016† X F166

† US 88-1016 = CP 65-357 X *S. spontaneum* 'NG 28-292'; US 88-1024 = (NCo 310 X *Miscanthus violaceum* 'US 56-42-3') X *S. officinarum* 'Sylva'; and SM 79016 = F153 X *M. sinensis* 'TM 75-30'.

‡ SM 8136 was introduced from Taiwan Sugar Research Institute, Tainan, Taiwan, R. O. C.

Non-antheral transformation originated from the anther primordia that, under normal conditions, would develop into anthers, but the transformation took place before the anther differentiation had started. One or two stigmas with a spoon-like carpel arose at the base (Fig. 1 E-G and Fig. 2 D-F). Among plants with the non-antheral transformed stigmas, most exhibited flowers with 5 stigmas. One BC_2 plant, SM 8136-7, from a sugarcane X *Miscanthus* cross, was characterized by flowers all bearing 5 stigmas (Fig. 1 E). Besides 5 stigmas, there were 6 or more stigmas per flower observed in some plants (Fig. 1 G and Fig. 2 E-F). Formation of multiple stigmas may be caused by irregular differentiation of anther primordia resulting in as many as 4 stigmas emerged at one carpel (Fig. 2 G). This situation was common in most non-antheral transformed plants, especially in SM 8136-10, which had 12 or more stigmas in more than 50% of the flowers examined. Double ovaries (Fig. 2 H), three stigmas from one ovary (Fig. 2 G) or four anthers (Fig. 2 I) were found among flowers in the BC_1 generation derived from a cross between CP 65-357 and *S. spontaneum*. Two BC_1 populations, X89-279 and X89-280, were used to further examine the floral organ abnormalities as shown in Table 4.

The abnormalities included three stigmas arising from one ovary, four stigms arising from one ovary, stigmas arising at the tip of the anther, stigmas arising from anther promordia, four stigmas or anthers occurred in one flower, and double ovaries in one flower. In both X89-279 and X89-280, more than 20% of their flowers examined were abnormal.

Table 2. The percentage of flowers with different numbers of stigmas among parental clones, F_1 and BC_1 progeny derived from interspecific crosses between *S. spontaneum* and sugarcane or *S. spontaneum* and *S. officinarum*.

	Number of Stigmas per flower											
Clone	2	3	4	5	6	7	8	9	10	11	>12	Other†
Uganda	95											5
CP 70-1133	98											2
US 88-1002			4	43	26	14	9	4	1			
US 88-1003				1	10	27	25	20	15	2		
CP 84-222	100											
X89-216-1		5	31	37	21	6						
X89-216-2				34	34	21	11					
X89-216-3				77	22		1					
X89-216-4				6	17	26	32	10	8	1		
US 84-1016	97											3
X89-279		14	11	20	11	14	11				17	
N6-1	92	8										
N6-2	100											
N6-3	100											
N6-4	100											
N25-1	29	29	36	6								
N25-2‡	38	52	5	5								
N25-3‡	11		11	67	11							
N26-1	72	20	4	4								
N26-2	22	22	56									
N26-3	57	43										
N26-4‡	38	12	50									
N26-5	64	36										
N26-6	27	67	6									
N26-7	100											
N27-1	100											
N27-2	100											
N27-3	100											
N27-4	92	8										
N27-5	100											
X793-1	100											
X793-2	100											
X793-3	100											
X793-4	95	5										

† Two styles combined into one, but two stigmas remained separate; two ovaries occurred within one flower; or three to four stigmas arose from a single ovary.

‡ Antheral stigma developed from the tip of anther.

The sex transformation revealed that the quantitative variation could be controlled by the timing and site of gene expression. In *Arabidopsis thaliana*, identity of floral organs is determined by homeotic genes, which are expressed in specific regions of the developing flower (7). A similar activation of floral homeotic genes might control the antheral and non-antheral transformation in sugarcane and related grasses. Antheral transformation in *Saccharum* complex could be caused by both environmental and genetic factors (5). One of the causes could be the interaction between cytoplasm and nucleus like the cytoplasmic male sterility found in many plant species (3).

The data also indicated that the frequency of the antheral transformation among the interspecific hybrids was consistently higher when *S. spontaneum* was used as female parent than when it was used as male parent (Table 2). These results confirmed the earlier observations reported by Kandasami (4) and Krishnaswami (5). When the antheral-transformed hybrids were selfed or used as female parents and crossed with normal male sugarcane cultivars, their F_2 or BC_1 progeny showed a similar antheral transformation as did the parents of the F_1. Results indicated that the antheral transformation might not be confined to the crosses with *S. spontaneum* as female parent. There were a few instances, such as backcross progenies from US 88-1016 (=CP 65-357 X *S. spontaneum* 'NG 29-292'), that showed a wide range of antheral and non-antheral transformations (Table 4). The BC_1 plants derived from intergeneric crosses between sugarcane and *Erianthus* or *Miscanthus* also produced such transformation (Table 3). Genetic homology might exist among genera in the *Saccharum* complex.

Table 3. The percentage of flowers with different numbers of stigmas among parental clones and their F_1, F_2, or BC_1 progeny from intergeneric crosses between sugarcane and *Erianthus* or between sugarcane and *Miscanthus*.

	Number of stigmas per flower											
Clone	2	3	4	5	6	7	8	9	10	11	>12	Other†
US 88-1024	84											16
CP 89-901	95											5
X89-280-4‡	43			7								50
US 84-1030‡				53	40	7						
US 88-1029							10	7	60	17	7	
x81-27-1§		3	23	73	1							
X81-27-2§		3	17	75	5							
X81-27-3§		66	31	3								
X81-27-4§	52	33	14									
X81-27-5§	1	5	42	50	2							
SM 8136-1‡§	100											
SM 8136-6‡§				3	20	37	33	7				
SM 8136-7‡§				100								
SM 8136-8‡§				43	27	17	13					
SM8136-10‡§						3			27	20	50	

† Two styles combined into one, but two stigmas remained separate; two ovaries occurred within one flower; or three to four stigmas arose from a single ovary.

‡ Individual plants derived from self-pollination of parental clone X81-27 or SM 8136.

§ Antheral stigma developed from the tip of anther.

Antheral transformation not only reduced the number of normal anthers that would produce some fertile pollen (5), but also interfered with pollination by producing longer or abnormal stigma (6). Self pollination was impossible in the non-antheral transformation since the anthers had turned into pistils. The original pistils, however, remained functional. When they were used as female parents and pollinated with normal pollen, few seed could be obtained. The seed set on some F_1 hybrids and BC_1 progenies are shown in Table 5. Antheral and other related transformations significantly reduced the number of viable seeds. We did not examine these transformed anthers for pollen.

The floral organ abnormalities in the first and following generations of interspecific and intergeneric crosses could have significant impact on sugarcane breeding. The antheral and related transformations could be a barrier in introducing the *S. spontaneum* cytoplasm into commercial cultivars in order to broaden the cytoplasmic base of the current commercial cultivars. The lower seed set would reduce the size of the hybrid population resulting in poor breeding efficiency. Information obtained from this study should provide a basis for sugarcane breeders to esablish more effective breeding strategy for the germplasm utilization of *S. spontaneum* and related genera to improve commercial cultivars.

Table 4. Percentage of flowers with antheral or non-antheral transformations examined in two BC_1 populations.

	Type of transformations†						
Population	3S	4S	S/A	S/NA	4A	DO	N
X89-279‡	13.60	3.95	1.32	0.44	3.95	0.88	75.86
X89-280‡	3.33	2.22	2.22	1.11	11.11	2.22	77.79

† N = normal flower with two stigmas and three anthers; 3S = 3 stigmas arose from one ovary; 4S = 4 stigmas arose from one ovary; S/A = stigma arose at the tip of the anther; S/NA = stigma arose from anther primordium; 4A = 4 stigmas or anthers occurred in one flower; and DO = double ovaries in one flower.

‡ X89-279 = BC_1(US 88-1016 X CP 85-1845) and X89-280 = BC_1(US 88-1024 X CP 86-901).

Table 5. Estimated seed set of some anther-transformed F_1 and checks.

Female parent	No. of tassels	Fuzz g/tassel	No. viable seeds/g†	No. viable seeds/tassel
1989/90 Flowering Season				
US 88-1001	6	5.4	0.5	2.7
US 88-1002	9	10.0	0.2	2.0
US 88-1003	25	11.5	1.2	13.8
US 88-1004(CK‡)	18	4.4	21.3	93.7
1991/1992 Flowering Season				
US 88-1003	2	10.2	1.0	10.2
X81-27-1	4	2.4	0.5	1.2
X81-27-3	4	1.8	0.5	0.9
X81-27-5	6	4.1	3.0	12.3
US 90-1074(CK‡)	1	10.4	174.0	1,809.6

† Determined by germination test based on number of seedlings per gram of fuzz.

‡ No anther-transformed flowers were observed in plants used as checks.

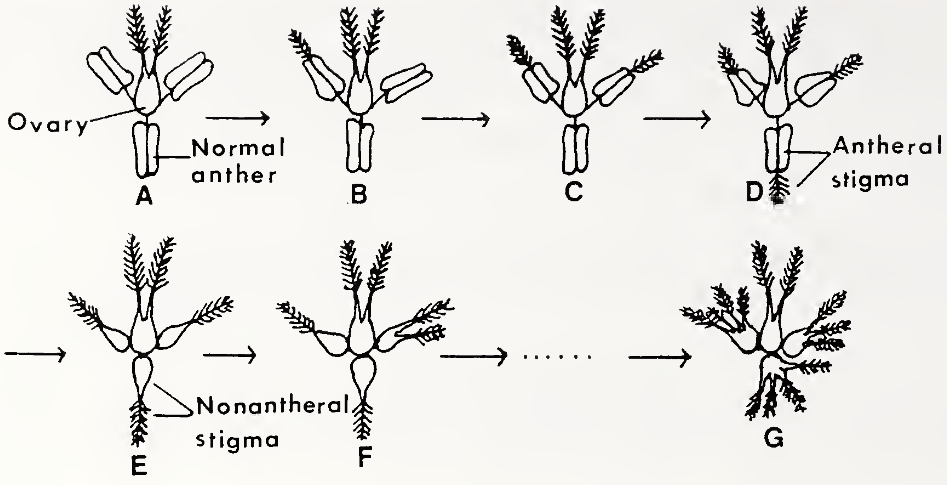

Fig. 1. The illustrative transformations of anther into stigma(s) and anther primordium into nonantheral stigmas.

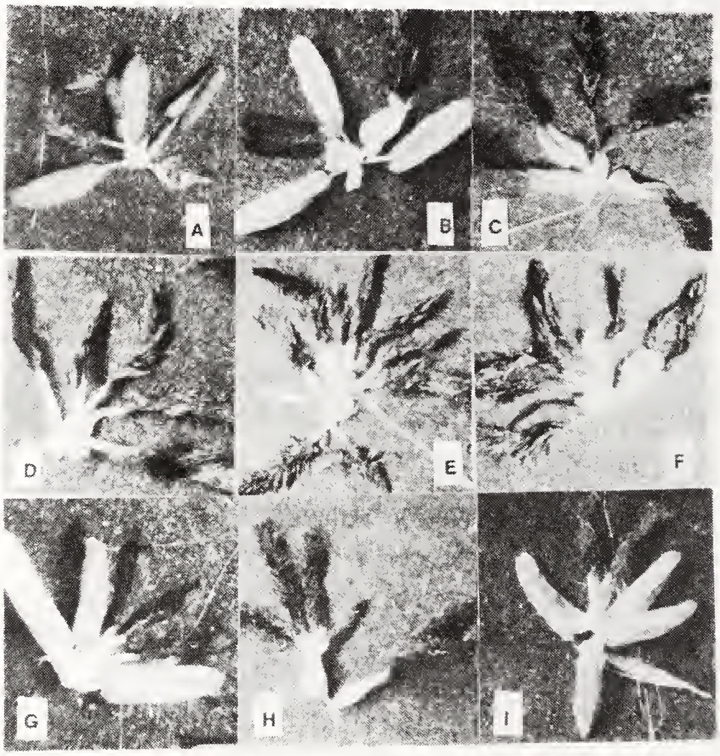

Fig. 2. Antheral or non-antheral transformations in interspecific and intergeneric hybrids and their progenies of *Saccharm*. (A) Normal flower with three anthers and two stigmas (*S. spontaneum* "Uganda"). (B) One of four anthers transformed into antheral stigma (89-279-4). (C) Three stamens transformed into antheral stigmas (X89-279-4). (D) Three non-antheral stigmas arose from three anther primordia (X89-216-2). (E) Seven non-antheral stigmas plus two normals (US 88-1002). (F) Callus formed at the base of non -antheral stigmas (US 88-1002). (G) Three stigmas arose from one ovary (X89-279-4). (H) Double ovaries in one flower, one of the has four stigmas (X89-279-4). (I) Four anther arose from one flower (X89-279-4).

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FIELD EVALUATION OF CHECK PLOT ADJUSTMENTS TO CONTROL ENVIRONMENTAL HETEROGENEITY IN AN UNREPLICATED SUGARCANE TRIAL[1]

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ABSTRACT

In the early selection trials of breeding programs, large numbers of entries are often tested in unreplicated tests. These tests confound genotypic and environmental effects and consequently limit gains from selection. This study evaluates the ability of several different adjustment models to control environmental heterogeneity in an unreplicated test and to improve sugarcane (*Saccharum* spp. hyb.) selection decisions. In 1989, 600 unreplicated clones and corresponding checks were measured for stalk number, stalk diameter and stalk height. Check plots were placed every fifth row in every fifth column. One hundred fifty of these clones were advanced to the next stage. The advanced clones were replicated two times at two locations in 1990 and measured for stalk number, stalk diameter, stalk height, cane yield and sugar yield. The replicated Increase Trial mean was used as an estimate of a clone's true genotypic value. Adjustment models were fit to the unreplicated clonal data and compared by their ability to describe field variation using model R^2 and F-tests for lack-of-fit. The covariate models fit the data better than the models without covariates (fertility index and row-column). However, no adjustment model was better than unadjusted yields at retaining the best clones as determined by replicated means. Severe weather and genotype by environment interaction between testing stages were the most likely explanations for failure of the adjustments to improve selection decisions.

INTRODUCTION

An objective of initial breeding program selection trials is to most efficiently retain superior germplasm for further testing. Breeders generally avoid replicated yield trials in these early stages due to the large number of lines to be evaluated and limited seed material availability. Replicated yield testing is postponed until the number of lines is reduced by subjective evaluation and unreplicated yield tests. Unreplicated yield tests are, however, inaccurate and may give estimates biased by environmental effects.

Several approaches have been used to increase the power of unreplicated trials (Baker and McKenzie, 1967; Ball et al. 1993; Bos and Hennink, 1991). One approach to correcting within field environmental effects is to replicate a control line throughout the field and adjust test line yield by the control line yield. Federer's (1956) augmented design (AD) uses control lines in a standard design, such as the randomized complete block or the latin square, and places them in a split plot arrangement. Test lines and one control line are randomly assigned to sub-plots within a whole plot. Control line performance is used to estimate block effects and residual error. Block effects are used to adjust test lines and the residual error is used to test differences among test lines.

The modified augmented design (MAD) maintains the split plot structure of the AD but arranges test plots so that whole plots are square, or nearly so, and assigns the control line to the center test

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plot (Lin and Poushinsky, 1983). The purpose of the square arrangement is to ensure homogeneity within whole plots since the center of each test plot is nearly equidistant from the center of the check plot. Every test plot within a whole plot receives the same adjustment. The systematic arrangement of control lines gives biased error estimates but a better representation of field variability.

A simulation study (Lin et al., 1983) revealed the potential of the MAD to control two-way and multidirectional heterogeneity. They used three adjustment methods to correct for field heterogeneity among 96 different cases of varying fertility gradients and random errors. The most effective method, adjustment by regression, produced efficiencies relative to no adjustment of at least 100% in all but one case. Use of the MAD in soybean trials showed the design generally more efficient than no adjustment with some traits responding better than others (Lin and Voldeng, 1989). The design has also been effective in reducing environmental variation in barley (May et al., 1989) and potato (Schaalje et al., 1987) variety trials when measured by relative efficiency. May et al. (1989) noted a large change in ranking but a small change in yields after adjustment. No reported study has compared adjusted and unadjusted yields and rankings to independent, replicated values of the test lines.

Fitting a response surface model assumes a smooth trend plus random error. The advantage of response surface adjustment models over blocking adjustments is that adjacent plots are considered more similar than distant plots. Warren and Mendez (1982), using uniformity trial data, found eighth order polynomials generally beneficial when trials were moderately or highly sensitive to blocking choices. Kirk et al. (1980) determined the optimal response surface by examining all possible regression models up to the eighth order. Response surfaces analysis in a standard design was always more efficient than the standard design alone (Kirk et al., 1980).

Sugarcane is a clonally propagated perennial. In Louisiana, a crop is harvested each fall for three years (plant-cane, first-ratoon, second-ratoon crops) before a field is replanted. The Louisiana Sugarcane Variety Development Program, conducted by the Louisiana Agricultural Experiment Station of the LSU Agricultural Center, uses three unreplicated testing stages. The ratoons of some 70,000 transplanted seedlings are allowed to over-winter to screen for winter hardiness. From the first-ratoon seedling crop about 3000 genotypes are advanced to first clonal trials (FCT) based on a subjective evaluation for stalk quality (stalk weight, stalk diameter, stalk height, and the absence of pith, tube, lodging, disease and insect damage) and percent soluble solids in the juice as determined by hand refractometer reading (hand Brix). Clones advanced to FCT are planted in 1.9 m x 1.9 m single-row plots with 0.6 m alleys, in paired rows of mostly full-sib families. Advancement to the second clonal trial (SCT) is based on FCT cane yield rating, stalk quality, and hand Brix. SCT consist of 600 to 1000 clones randomly planted in single-row plots 4.9 m x 1.9 m with a 1.2 m alley between plots. SCT is the first stage at which collection of objective data is feasible. Initial SCT selection is based on SCT stalk quality and stalk number. Selected clones are screened for Brix using a hand refractometer, and those 200 to 300 which compare favorably to a commercial check are planted in replicated increase trials (IT). Increase trial plots are the same size as the SCT plots.

Our objective was to test whether a statistical approach could be used to adjust for environmental effects and improve selection decisions among SCT clones. MAD adjustment models, a row-column covariate model and response surface adjustments were examined. Adjustments were considered effective if they adequately fit the data and retained the best clones as determined by unadjusted, independently replicated test line means.

MATERIALS AND METHODS

In 1989, 640 SCT genotypes were planted at the St. Gabriel Research Station, St. Gabriel, LA (SGRS) as per the MAD with two important differences. First, whole plots were not square or arranged in the recommended design for rectangular plots (Lin and Poushinsky, 1985). Whole plots contained 25 subplots in a five row by five column arrangement. Second, only one control, the commercial variety, CP 70-321, was used, and no control subplots were planted. All genotypes were measured for stalk number, stalk diameter, and stalk height. One hundred-fifty SCT clones advanced to IT were replicated four times among two locations, SGRS and the Iberia Research Station (IRS), near Jeanerette, LA. Plots were the same size as SCT plots but were planted as randomized complete blocks. Increase trial genotypes were measured for stalk number, stalk diameter, and stalk height.

Lin and Poushinsky (1983) suggested three adjustment models for the MAD. Method 1, the row-column method, adjusts whole plots based on the deviation of check row and column means,

$$Y'_{ij(k)} = Y_{ij(k)} - (\bar{X}_{i.} - \bar{X}_{..}) - (\bar{X}_{.j} - \bar{X}_{..}) \qquad \text{[Method 1]}$$

where,

$Y'_{ij(k)}$ = adjusted yield of the k-th test line in whole plot i, j,

$Y_{ij(k)}$ = unadjusted yield of the k-th test line in whole plot i, j,

$\bar{X}_{i.}$ = mean of all check plot yields in row i,

$\bar{X}_{.j}$ = mean of all check plot yields in column j, and

$\bar{X}_{..}$ = mean of all check plots.

The fertility index (Method 2) adjusts whole plots by the deviation of the corresponding check plot from the overall mean of check plots,

$$Y'_{ij(k)} = Y_{ij(k)} - (X_{ij} - \bar{X}_{..}) \qquad \text{[Method 2]}$$

where,

X_{ij} = yield of the check in whole plot i, j.

The regression adjustment (Method 3) treats the deviations of the check plots from the overall mean as a covariate,

$$Y'_{ij(k)} = Y_{ij(k)} - b_1(X_{ij} - \bar{X}_{..}) \qquad \text{[Method 3]}$$

where,

$b_1 = \dfrac{\Sigma\Sigma(\bar{Y}_{ij(.)} - \bar{Y}_{..(.)})(X_{ij} - \bar{X}_{..})}{\Sigma\Sigma(X_{ij} - \bar{X}_{..})^2}$ regression of the mean of all test plots within a whole plot on its check plot,

$\bar{Y}_{ij(.)} = \Sigma Y_{ij(k)}/n_k$ mean of all test plots within a whole plot, and

$\bar{Y}_{..(.)} = \Sigma\Sigma\Sigma Y_{ij(k)}/(n_i n_j n_k)$ mean of all test plots.

An extension to method 3 is a row-column regression (Method 4) where the row and column deviations are used as covariates,

$$Y'_{ij(k)} = Y_{ij(k)} - b_2(\bar{X}_{i.} - \bar{X}_{..}) - b_3(\bar{X}_{.j} - \bar{X}_{..}) \qquad \text{[Method 4]}$$

where,

$b_2 = \dfrac{\Sigma\Sigma(\bar{Y}_{i.(.)} - \bar{Y}_{..(.)})(\bar{X}_{i.} - \bar{X}_{..})}{\Sigma\Sigma(\bar{X}_{i.} - \bar{X}_{..})^2}$ regression of the mean of all test plots in a row of whole plots on the mean of checks in that row,

$\bar{Y}_{i.(.)} = \Sigma\Sigma Y_{i.(.)}/(n_j n_k)$ mean of all test plots in a row of whole plots,

$b_3 = \dfrac{\Sigma\Sigma(\bar{Y}_{.j(.)} - \bar{Y}_{..(.)})(\bar{X}_{.j} - \bar{X}_{..})}{\Sigma\Sigma(\bar{X}_{.j} - \bar{X}_{..})^2}$ regression of the mean of all test plots in a column of whole plots on the mean of checks in that column, and

$\bar{Y}_{.j(.)} = \Sigma\Sigma Y_{.j(.)}/(n_i n_k)$ mean of all test plots in a column of whole plots.

Categorical variables can be included in each design to allow rows and columns within a whole plot to vary. Categorical analysis allows for the possibility that whole plots are not homogeneous. Method 5 is a regression model with categorical variables,

$$Y'_{ij(k)} = Y_{ij(k)} - b_1(X_{ij} - \bar{X}_{..}) + b_4 z_1 + \ldots + b_{14} Z_{10} \qquad \text{[Method 5]}$$

where,

$z_1, \ldots, z_5$ = rows 1 through 5 within a whole plot; value equals one,
$z_6, \ldots, z_{10}$ = columns 1 through 5 within a whole plot; value equals one,
$b_4, \ldots, b_{14}$ = regression of the test plot mean of row 1 through column 5 within a whole plot on its check plot.

Method 6 is a row-column regression model with the same catagorical variables as used in method 5.

$$Y'_{ij(k)} = Y_{ij(k)} - b_2(\bar{X}_{i.} - \bar{X}_{..}) - b_3(\bar{X}_{.j} - \bar{X}_{..}) + b_4 z_1 + \ldots + b_{14} z_{10} \qquad \text{[Method 6]}$$

Three continuous response surface models were fit to check yields. The full model used all 23 degrees of freedom to fit a seventh order polynomial of all row, column, and interaction terms except those that were a linear combination of lower order terms or:

$$\begin{aligned} Y = {} & C + R + CR + C^2 + R^2 + C^2R + CR^2 + C^3 + R^3 + C^3R + C^3R^2 \qquad \text{[Method 7]} \\ & + C^2R^3 + C^3R^3 + C^4 + R^4 + CR^4 + C^4R^2 + C^2R^4 + C^4R^3 + C^3R^4 \\ & + R^5 + CR^5 + C^2R^5 \end{aligned}$$

where R = row in whole plot, C = column in whole plot, RC = the row x column interaction, R^2 = the row squared etc. The full model fits check plot yields perfectly and does not allow for a random error component. The SAS Proc Reg procedure (1985) was used to fit the model to the best possible 23 model terms.

The second order model fit all first and second order row, column, and interaction terms.

$$Y = R + C + RC + R^2 + C^2 \qquad \text{[Method 8]}$$

The simplest model (Method 9) used only those second order model terms significant at $\alpha \leq 0.10$. Model terms varied with the trait. The terms used were $Y = R^2$ for stalk number, $Y = C$ for stalk diameter, and $Y = RC$ for stalk height.

For each model, predicted check yields at each test plot were used as a covariate to determine adjusted yields. Only one degree of freedom was used by each response surface adjustment. The estimation of the response surface (requiring up to 23 degrees of freedom) was considered separate from the adjustment of test yields.

Thirty SCT clones were dropped from the analysis because they did not fall within a complete whole plot. One SCT check plot stalk number was erroneously recorded and so the entire whole plot was excluded. Sixteen IT clones were dropped because data were not recorded.

Row or column effects were dropped from the models when not significant. Ideally, row and column effects would be tested against an error term calculated from the additional control subplots (Lin and Poushinsky, 1983). Lacking these extra subplots, row and column effects were tested against the residual error. This error term is inflated and so yields a conservative test of row and column effects.

Adjustment models were fit and compared by model R^2, the F-test for lack-of-fit, and rank correlations between adjusted unreplicated yields and the replicated IT means. Replicated IT means were used as a measure of a clone's true genotypic worth. The number of the best genotypes retained by each adjustment was determined.

RESULTS AND DISCUSSION

The record-setting freeze of December, 1989 seriously affected IT mean yields and variances, especially at the SGRS (Table 1). Fifteen IT plots at the SGRS did not survive, which is an unusual event. Although mean stalk number, stalk diameter, and stalk height were somewhat diminished at the SGRS, the largest effect was on the variances of these traits. Inflation of two to six times the variances of SCT test were experienced. The components were not so affected at the IRS. The result of such variance inflation was to obscure genotypic variability with error variance to a greater degree than usually experienced.

Table 1. Population sizes, means and variances for stalk number, stalk diameter and stalk height for Second Clonal Trial test and check plots and Increase Trial test plots at each location.

Testing Stage	Plot Type	Site[1]	Stalk Number			Stalk Diameter			Stalk Height		
			-------- no m^{-2} -------			--------- cm ----------			-------- cm -----------		
			n	$\overline{X}$	σ^2	n	$\overline{X}$	σ^2	n	$\overline{X}$	σ^2
Second Clonal (SCT)	Test	SGRS	616	6.61	3.17	616	2.45	0.06	616	286	538
	Check	SGRS	23	6.65	1.09	24	2.57	0.02	24	279	259
Increase (IT)	Test	SGRS	149	5.30	8.14	149	2.32	0.38	149	213	3359
	Test	IRS	150	7.06	2.21	147	2.41	0.05	147	203	459

1 - SGRS = St. Gabriel Research Station, IRS = Iberia Research Station.

The impetus for a statistical method to adjust for field effects is that there is some spatial relationship in plot yields. For an adjustment to be effective it must fit that relationship. Model fit was used as the criterion for selecting an adjustment method. It is unlikely that a single adjustment will be effective for all fields or traits (Lin and Voldeng, 1989).

Based on model R^2, the row-column regression with categorical variables (Method 6) was the best model for stalk number (Table 2), the simplest response surface (Method 9) was the best for stalk diameter (Table 3), and the row-column regression (Method 4) was the best for stalk height (Table 4). The row-column regression with categorical variables model (Method 6) for stalk number had some lack-of-fit, but it was the smallest lack-of-fit for models with significant regressions. The models could not be improved with other categorical variable configurations. Results for the regression with categorical variables (Method 5) and the row-column regression with categorical variables (Method 6) are not given for stalk diameter (Table 3) or stalk height (Table 4) because no significant categorical variables could be found. The row-column (Method 1) and fertility index (Method 2) adjustments require no model degrees of freedom because the slope and intercept parameters are not estimated and assumed to be one.

The fertility index and row-column models (Methods 1 and 2) are poor choices for an adjustment model. These methods assume the relationship between the check and the tested genotypes is unity. This would be true if genotype x environment interaction variance (GE) and the error variance equaled zero, and whole plots were environmentally uniform, an unlikely case. To avoid over adjustment it is better to characterize that relationship and include it in the adjustment model. Because the parameters are not the least squares solutions, the sums of squares are not minimized and can be larger than the corrected total sum of squares (Tables 2, 3, 4). This precluded use of the R^2 to compare their effectiveness with the other models. It is also more difficult to obtain adjusted values. With covariate models, the residuals from regression can be used as adjusted values. For the fertility index and row-column models, the regressions must be made directly with the matrices or the adjustments made algebraically.

Table 2. Sums of squares and degrees of freedom for model, error, lack-of-fit, pure error, R^2 and F-test of LOF for stalk number.

	Adjustment Method	Sums of Squares (degrees freedom)					F-test Lack-of-fit vs. Pure Error
		Model	Error	Lack-of-fit	Pure Error	R^2	
		---------- stalks m^{-2} ----------				%	
1	Row-Column	24386.2 (0)	27392.2 (551)	25813.2* (21)	1579.0 (528)	-	411.10*
2	Fertility Index	309.9 (0)	2492.2 (551)	886.6* (16)	1605.6 (534)	-	18.41*
3	Regression	6.90 (1)	1777.86 (550)	886.56* (16)	1605.64 (534)	0.39	18.43*
4	Row-Column Regression	89.58* (1)	1695.18 (550)	66.41* (4)	1628.77 (546)	5.02	5.56*
5	Regression + Categorical	27.77* (3)	1756.99 (548)	349.21* (56)	1407.78 (492)	1.56	2.18*
6	Row-Column Regression + Categorical	110.45* (3)	1674.31 (548)	109.74* (22)	1564.57 (526)	6.20	1.68*
7	Full Model Response Surface	0.28 (1)	1784.48 (550)	1066.83* (147)	717.65 (403)	0.16	4.07*
8	Second Order Response Surface	5.01 (1)	1779.74 (550)	564.91* (142)	1214.83 (408)	0.28	1.34*
9	Simplest Response Surface	8.31 (1)	1776.45 (550)	36.85 (8)	1739.60 (542)	0.47	1.44

* F-test significant at $\alpha = 0.05$.

An explicit assumption of the MAD, and all blocking adjustments, is homogeneity of whole plots. Smaller whole plots would increase homogeneity but would not necessarily account for directional effects. The correlation between the means of test plot neighborhoods of varying sizes and the corresponding check may give an indication of whole plot homogeneity (Table 5). The correlations were poor for neighborhoods involving all 25 subplots; the whole plot was simply too large and encompassed too much variability. However, even if the whole plots included the central nine subplots (3 rows x 3 columns), there was still no correlation between test plot mean and check yield. Assuming the recommended design for rectangular plots (Lin and Poushinsky, 1985), one row by three columns, only stalk number shows a significant correlation. A one row by three columns whole plot would miss the significant three rows by one column relationship for stalk number and diameter. For diameter this is the only significant relationship.

Table 3. Sums of squares and degrees of freedom for model, error, lack-of-fit, pure error and F-tests for stalk diameter.

Adjustment Method	Sums of Squares (degrees freedom)					F-test Lack-of-fit vs. Pure Error
	Model	Error	Lack-of-fit	Pure Error	R^2	
	cm^2				%	
1 Row-Column	3661.9	4055.3	4024.8*	30.5	-	3304.48*
	(0)	(551)	(21)	(529)		
2 Fertility Index	164.6	47.4	14.6*	32.84	-	60.52*
	(0)	(551)	(4)	(546)		
3 Regression	0.23*	33.0	0.12	32.84	0.69	0.50
	(1)	(550)	(4)	(546)		
4 Row-Column	0.17	33.01	0.99*	32.02	0.51	3.48*
Regression	(1)	(550)	(4)	(446)		
7 Full Model	0.03	33.15	7.69*	25.26	0.09	1.91*
Response Surface	(1)	(550)	(75)	(475)		
8 Second Order	0.09	33.09	1.82	31.27	0.27	1.31
Response Surface	(1)	(550)	(26)	(524)		
9 Simplest	0.84*	32.35	0.78	31.57	2.53	1.11
Response Surface	(1)	(550)	(12)	(538)		

* F-test significant at $\alpha = 0.05$.

If whole plots were homogeneous with respect to soil fertility, one would expect a positive relationship between test plot yield and check plot yield. That the one row by three columns correlation is negative and the three rows by one column correlation is positive indicates that there is more to environmental heterogeneity than simply soil fertility and that the variation is directional. For one row and three column configurations, plots join at their longest side. It is in this direction that interplot plant competition would be greatest. The negative effect of competition on yields is well documented (Bos and Hennink, 1991; Kempton, 1982). In the other direction, three rows and one column, a positive correlation exists for at least five test plots. While it is possible that a fertility isoquant spans 30.5 m (5 plots), since sugarcane tests are worked with single row equipment, the positive effect is likely due to tractor-induced effects such as cultivation, fertilization etc. Response surface adjustments can account for long range directional variation. Class variables can control short range variation, especially when due to a consistent competitive effect. A better approach may be to take into account directly the covariance structure between plots (Samra et al., 1989).

All adjusted and unadjusted yields were highly rank correlated with each other but poorly rank correlated with the independent unadjusted replicated IT mean (Tables 6, 7, 8). Except for fertility index (Method 2) adjusted stalk number and height, and row-column (Method 1) adjusted stalk number, the choice of an adjustment model had no effect on the rank correlation with the replicated mean. The number of best genotypes retained, as determined by the replicated mean, was completely unaffected by adjustment model choice (Tables 9, 10, 11). Even the fertility index (Method 2) and row-column (Method 1) adjustments performed well. Although there was some field variation accounted for by a spatial model, predictive ability was not improved.

Table 4. Sums of squares and degrees of freedom for model, error, lack-of-fit, pure error, R^2 and F-test of LOF for stalk height.

Adjustment Method	Sums of Squares (degrees freedom)					F-test Lack-of-fit vs. Pure Error
	Model	Error	Lack-of-fit	Pure Error	R^2	
	---------------------------- cm^2	--------------------------------				
1 Row-Column	42980696 (0)	41298034 (551)	41009503* (21)	288531 (529)	-	3580.37*
2 Fertility Index	1075919 (0)	488746 (551)	197638* (10)	291108 (540)	-	36.66*
3 Regression	561 (1)	301666 (550)	10558 (10)	21108 (540)	0.19	1.96
4 Row-Column Regression	4662* (2)	297565 (549)	2039 (2)	295526 (547)	1.54	1.89
7 Full Model Response Surface	2767* (1)	299460 (550)	280800* (20)	18660 (530)	0.92	400.34*
8 Second Order Response Surface	373 (1)	301854 (550)	268348* (57)	33506 (493)	0.12	69.27*
9 Simplest Response Surface	5 (1)	302222 (550)	89995* (131)	212370 (419)	0.00	1.36*

* F-test significant at $\alpha = 0.05$.

Total SCT variation (σ_T^2) can be separated into three components:

$$\sigma_T^2 = \sigma_G^2 + \sigma_E^2 + \sigma_S^2$$

where σ_G^2 = the genetic variance confounded with among year and location GE, σ_E^2 = random error variance, and σ_S^2 = spatial effects variance (Weber and Stam, 1988). In unreplicated tests σ_G^2 and σ_E^2 cannot be separated. If ($\sigma_G^2 + \sigma_E^2$) is much greater than σ_S^2, a spatial effects model could not account for enough variation to noticeably improve predictive ability (Weber and Stam, 1988). Using mean square pure error as an estimate of $\sigma_G^2 + \sigma_E^2$, then for stalk number, $(\sigma_G^2 + \sigma_E^2)/\sigma_T^2$ = 92%, 100% for diameter and 98% for height. Most of the variation in SCT yields then is due to genetic and random error components.

Table 5. Regression and correlation coefficients for check plot yield vs. mean test plot yields of various whole plot sizes and configurations.

		Whole plot configuration (row x column)					
		3 x 3	1 x 3	3 x 1	5 x 5	1 x 5	5 x 1
Stalk Number	b[1]	-0.453	-0.411	0.337	-0.306	-0.611	0.211
	r	-0.291	-0.530	0.352	-0.183	-0.534	0.203
	p	0.179	-0.009	0.010	0.403	0.009	0.352
Stalk Diameter	b	0.259	-0.072	0.287	0.585	-0.031	0.301
	r	0.159	-0.111	0.411	0.320	-0.033	0.307
	p	0.457	0.604	0.046	0.129	0.880	0.145
Stalk Height	b	0.071	0.050	0.131	-0.623	-0.208	0.108
	r	0.053	0.057	0.175	-0.194	-0.156	0.113
	p	0.807	0.794	0.413	0.364	0.468	0.600

1 - b = regression coefficient, r = correlation coefficient, and $P_{0.05}$ = probability that r $\neq$ 0.

Table 6. Stalk number rank correlations between Second Clonal Trial adjusted values and with Increase Trial means for each model.

Adjustment Method	Adjustment Method									Increase Mean
	1	2	3	4	5	6	7	8	9	
	n = 552									n=134
Unadjusted	0.92[1,2]	0.86	1.00	0.97	0.99	0.96	1.00	1.00	1.00	0.35[3]
Row-Col. (1)		0.94	0.90	0.86	0.90	0.86	0.92	0.91	0.93	0.26
Fertility Index (2)			0.82	0.80	0.81	0.79	0.85	0.84	0.87	0.20
Regression (3)				0.97	0.97	0.97	1.00	1.00	0.99	0.35
Row-Col. Reg. (4)					0.97	0.97	0.97	0.97	0.97	0.36
Reg.+Cat. (5)						0.99	0.99	0.99	0.99	0.35
Row-Col Reg.+Cat. (6)							0.97	0.97	0.96	0.36
Full Model Response Surface (7)								1.00	1.00	0.35
Second Order Response Surface (8)									0.99	0.35
Simplest Response Surface (9)										0.35

1 - All correlations significantly different from zero to at least α = 0.02.
2 - LSD for any two correlations = 0.094 at α = 0.05 when n = 552.
3 - LSD for any two correlations = 0.192 at α = 0.05 when n = 134.

Table 7. Stalk diameter rank correlations between Second Clonal Trial adjusted values and with Increase Trial means for each model.

Adjustment Method	Adjustment Method							Increase Mean
	1	2	3	4	7	8	9	
	---------------------------- n = 552						-------------------------------	n=134
Unadjusted	0.95[1,2]	0.88	1.00	1.00	1.00	1.00	1.00	0.35[3]
Row-Column (1)		0.93	0.90	0.97	0.95	0.96	0.96	0.36
Fertility Index (2)			0.91	0.89	0.87	0.89	0.89	0.34
Regression (3)				1.00	1.00	1.00	0.99	0.36
Row-Column Regression (4)					1.00	1.00	0.99	0.36
Full Model Response Surface (7)						1.00	0.99	0.35
Second Order Response Surface (8)							0.99	0.37
Simplest Response Surface (9)								0.37

1 - All correlations significantly different from zero to at least $\alpha = 0.02$.
2 - LSD for any two correlations = 0.094 at $\alpha = 0.05$ when n = 552.
3 - LSD for any two correlations = 0.192 at $\alpha = 0.05$ when n = 552.

Table 8. Stalk height rank correlations between Second Clonal Trial adjusted values and with Increase Trial means for each model.

Adjustment Method	Adjustment Method							Increase Mean
	1	2	3	4	7	8	9	
	------------------------------- n = 552						----------------------------	n=134
Unadjusted	0.94[1,2]	0.83	1.00	0.99	1.00	1.00	1.00	0.25[3]
Row-Column (1)		0.88	0.93	0.92	0.93	0.94	0.94	0.24
Fertility Index (2)			0.81	0.81	0.81	0.82	0.83	0.16
Regression (3)				0.99	1.00	1.00	1.00	0.25
Row-Column Regression (4)					0.99	0.99	0.99	0.25
Full Model Response Surface (7)						1.00	1.00	0.26
Second Order Response Surface (8)							1.00	0.25
Simplest Response Surface (9)								0.25

1 - All correlations significantly different from zero to at least $\alpha = 0.02$.
2 - LSD for any two correlations = 0.094 at $\alpha = 0.05$ when n = 552.
3 - LSD for any two correlations = 0.192 at $\alpha = 0.05$ when n = 134.

Table 9. Number of best and worst Second Clonal Trial genotypes (as determined by replicated Increase Trial mean) retained after selecting the best 50 genotypes by each adjustment method for stalk number[1].

	Adjustment Method	Best[2] 10	Best 20	Best 50	Worst 35
	No Adjustment	6	12	23	8
1	Row-Column	6	11	25	7
2	Fertility Index	5	10	25	7
3	Regression	7	13	22	8
4	Row-Column Regression	5	11	23	7
5	Regression + Categorical	7	13	23	7
6	Row-Column + Categorical	6	12	24	6
7	Full Model Response Surface	6	12	23	8
8	Second Order Response Surface	7	13	23	8
9	Simplest Response Surface	6	12	23	8

1 - Analysis performed only on those genotypes for which an IT mean was available (n = 134).
2 - Best as determined by replicated IT mean.

Table 10. Number of best and worst Second Clonal Trial genotypes (as determined by replicated Increase Trial mean) retained after selecting the best 50 genotypes by each adjustment method for diameter[1].

	Adjustment Method	Best[2] 10	Best 20	Best 50	Worst 35
	No Adjustment	7	13	29	7
1	Row-Column	7	14	30	7
2	Fertility Index	7	12	29	10
3	Regression	7	13	29	7
4	Row-Column Regression	7	13	27	7
7	Full Model Response Surface	7	13	27	7
8	Second Order Response Surface	7	13	28	7
9	Simplest Response Surface	7	13	27	7

1 - Analysis performed only on those genotypes for which an IT mean was available (n = 134).
2 - Best as determined by replicated IT mean.

Table 11. Number of best and worst Second Clonal Trial genotypes (as determined by replicated Increase Trial mean) retained after selecting the best 50 genotypes by each adjustment method for height[1].

Adjustment Method		Best[2] 10	Best 20	Best 50	Worst 35
	No Adjustment	5	12	24	10
1	Row-Column	5	13	24	8
2	Fertility Index	5	12	22	10
3	Regression	5	13	25	9
4	Row-Column Regression	5	13	24	9
7	Full Model Response Surface	4	12	24	9
8	Second Order Response Surface	5	13	24	10
9	Simplest Response Surface	4	12	24	9

1 - Analysis performed only on those genotypes for which an IT mean was available (n=134).
2 - Best as determined by replicated IT mean.

Genotype by environment interaction among IT and SCT tests, due to weather and the range of locations, likely affected IT means and therefore predictive ability. Cane yield and sugar yield means at each location were poorly correlated ($r_{\text{cane yield}}=0.168$; $r_{\text{sugar yield}}=0.190$). This suggests that the genotype by environment interaction between IT locations was high. However, the objective of a breeding program is to develop broadly adapted varieties. These genotypes will eventually be ranked by their yields across all environments. The early stages of the program must retain the genotypes that have the potential to perform well in other environments.

Large within-test random error variances and year to year GE variance result in low yield estimate repeatability between stages and limit predictive ability. If random error is the major problem, there is no choice but to use replicated tests. This may require a reduction in test size.

For a check plot adjustment to be useful, one must be able to identify the best adjustment method in the year that selections are made. Relative efficiency has been used to compare adjustment methods, but it does not always identify the best method (Lin et. al, 1983, May et. al, 1989). Relative efficiency is essentially a ratio of variances. If the sums of squares is not a least squares solution, as in the row-column (Method 1) and the fertility index (Method 2) methods, then relative efficiency is a poor criterion for choosing an adjustment method. A comparison of relative efficiencies for covariate methods may be an effective way to identify the best adjustment method.

For an adjustment model to be effective, it must fit the data and retain more of the better genotypes than using unadjusted yields. The covariate models discussed (Methods 3 - 9) fit the SCT data better than the row-column (Method 1) or fertility index (Method 2) adjustments, but no adjustment method retained the best IT genotypes better than using unadjusted yields (Tables 9, 10 and 11). A model that takes into account the exact covariance structure between plots would have the best chance of success. The categorical analyses (Methods 5 and 6) are a step in this direction, but a more explicit statement of the covariance seems necessary.

Although extreme weather events probably negatively affected the results of the study, the findings do not indicate any statistical adjustment to unreplicated data would improve selection efficiency.

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DEXTRAN INDUCED SUGAR LOSS TO MOLASSES
(THE LOUISIANA EXPERIENCE)

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ABSTRACT

During the 1991 Louisiana sugar processing season a severe freeze provided an opportunity for determining, under factory conditions, the scope of dextran-induced sugar loss to molasses. The rise in molasses purity per 1000 ppm on Brix of dextran in the mixed juice averaged 2.5 points. This elevation varied with dextran concentration, geographical region and factory operating conditions. The time required for an individual factory to recover from dextran shock also varied, but averaged about three weeks. The sugar loss was lower than that reported in laboratory studies for equivalent dextran concentrations. However, the concentration of dextran in juice that results in significant financial loss was 3 fold lower than the amount of dextran that produces 250 MAU in sugar.

INTRODUCTION

The criterion for molasses exhaustion is "target purity." The definition of the "target" varies across the sugar world. In Louisiana the current target is the ASI target (8). Generally, the "target" is the generally achievable level of molasses exhaustion based on some variation of the criteria developed by Foster *et al* (4). They determined "target" from experimental crystallizations and developed a formula based on a correlation of viscosities of saturated massecuites with their reducing sugar and sulfated ash contents. Similar correlation formulas are now the basis for target purity determinations in all parts of the world.

Compounds that alter the viscosity of the massecuite alter the correlation between viscosity and the target. Generally they also produce adverse effect on sugar crystallization. Viscosity rises ultimately increase the amount of sugar found in the final molasses. Polysaccharides, particularly dextran, alter molasses true purity to an unquantified extent. Processing problems attributed to dextran include increased juice viscosity (5), poor clarification (6) and crystal elongation (1). The most damaging effects of high levels of dextran are seen on crystal growth. Sucrose crystallizes as elongated crystals in the presence of dextran. Commercially, this results in sugar loss to molasses. Dextran can reach high levels, up to 10,000 ppm on Brix have been reported in syrups. It is well established that when dextran is high in sugar factories, boiling house performance drops. The performance change has been attributed to viscosity alterations, changes in heat transfer characteristics of the pans, and changes in crystallization characteristics of the sucrose.

The existence of quality points for dextran in raw sugar contracts provided a standard for economic loss due to dextran. Factory operations are geared to minimize this loss by blending high and low dextran sugars. However, there is a less obvious but no less serious economic loss due to dextran. This is the loss of recoverable sugar to molasses. It is seen as a rise in the true purity of the final molasses, or an inability to achieve the "target." Laboratory studies in Australia have shown that a loss of 1.2 to 1.4 purity points can be expected for every 1,000 ppm on Brix of dextran in the molasses. This is equivalent to about 250 ppm on Brix in mixed juice (7). The difficulty in determining actual dextran induced losses in operating factories has limited loss estimates to these laboratory studies. The dextran induced sugar loss may also be expected to be a function of factory operation as well as the dextran levels. A unique combination of circumstances, a sudden freeze followed by a warm spell, occurring during an extensive program of molasses and dextran monitoring, made possible the determination of dextran induced sugar loss to molasses in operating factories.

MATERIALS AND METHODS

Sampling

Weekly composite samples of final molasses were collected from 13 different Louisiana raw sugar mills throughout the 1991 processing season.

Dextran Analysis

Daily dextran values (Haze) on sugar were obtained from each of the mills supplying molasses samples. The values were averaged to produce a dextran weekly number. Dextran in mixed juice was estimated from sugar dextran values using the partition value of 30% mixed juice goes to sugar reported by Day and Otts (3).

Molasses Analysis

True purity was determined by liquid chromatography on a Bio-Rad Aminex HPX-87K analytical column (ion-exchange resin in a K+ form) at 85°C using a Waters 410 RI detector. Sucrose was determined from 20 microliter injections of solution (2 g sample diluted to 1,000 ml) filtered through 0.45 micron membrane. Additional parameters were: liquid phase: 0.05 M K_2SO_4 in distilled water, flow rate 0.5 ml/min, integration with a Spectra-Physics 4270 integrator/recorder. Brix was determined by refractometry of a 1:1 diluted samples at 20°C.

RESULTS and DISCUSSION

During the fourth week of the 1991 cane harvest season (Oct 22-28) most of the Louisiana sugar producing region experienced a killing freeze, followed by period of warm, rainy weather. The sugar mills, without exception, experienced severe processing problems after the freeze and reported high levels of dextran in sugar. The following week (Oct 20-Nov 4) the nighttime ambient temperatures dropped below the point where dextran development was favored. Processing problems moderated as the temperatures dropped. In 1991, the Audubon Sugar Institute conducted a detailed survey of both dextran in sugar and molasses exhaustion for each Louisiana mill. The freeze provided an opportunity to document sugar losses to molasses as a function of the dextran brought into the factories.

The sugarcane producing regions in Louisiana follow flood plains of three rivers. They are the flood plains of the Mississippi river, Bayou Lafourche and Bayou Teche. In order to minimize natural differences between regions, factories were grouped according to the region from where they draw the majority of their sugarcane. All three sugarcane producing region of the state, Teche, Lafourche and Mississippi showed similar dextran profiles. The average profile for dextran in juice for Louisiana in 1991 in given in Figure 1.

A "practical target" for molasses exhaustion was established for each sugar mill participating in this study. The "practical target" was determined as the lowest molasses true purity achieved by that factory during the processing season. In most cases, this was the level achieved during week three (Oct 15 - 21). This target for molasses exhaustion is not necessarily the best that can be achieved with this particular molasses, i.e., the "target purity," but rather the best the individual factory achieved in 1991. The average "practical target" for Louisiana as well as variation between producing regions are given in Table 1. Dextran in juice concentrations 'tracked' final molasses true purity. The sharp increase in dextran entering the factories after the freeze produced parallel increases in final molasses true purities (Figure 2A). The average profile for dextran and true purity of molasses, by week is typical for the profiles seen at individual mills (Figure 2B). The major difference observed between individual mills was the in the length of time required to return molasses exhaustion to pre-freeze levels (Table 2). Of the mills that were monitored, 27% were unable to lower their molasses purity to pre-freeze levels prior to end of the harvest season. The ability of a factory to recover from a dextran shock is probably a function a wide variety of factors. It is obvious that further investigation into differences in pan-crystallizer design and operating practices on dextran elimination is warranted.

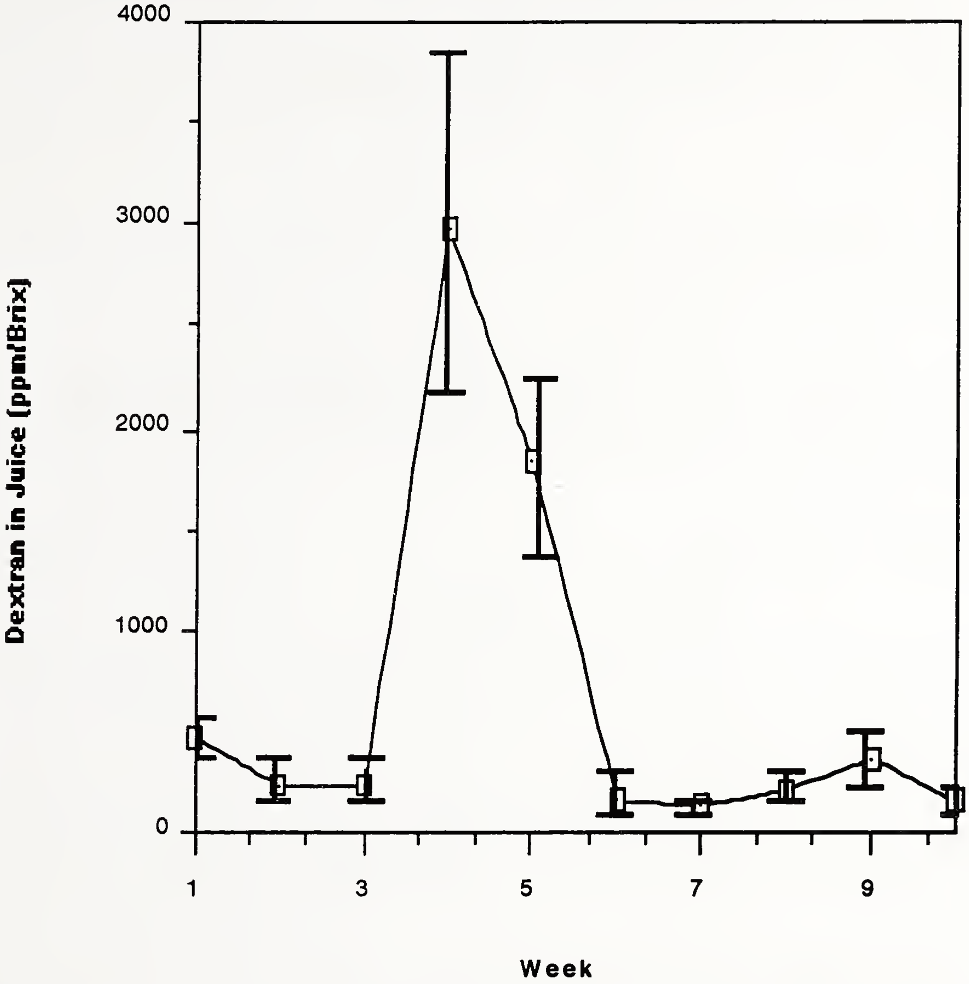

Figure 1. Dextran in mixed juice by week of processing for Louisiana in 1991. Values are given as the means +/- the standard error.

Table 1. The 1991 "Practical Target" for Louisiana Molasses Exhaustion

Region	n	target (average)	standard deviation	minimum	maximum
Lafouche	2	41.02	1.584	39.90	42.14
Miss	3	38.92	1.390	37.55	40.33
Teche	8	41.22	2.015	38.56	44.93
Louisiana	13	40.38	1.557	37.55	44.53

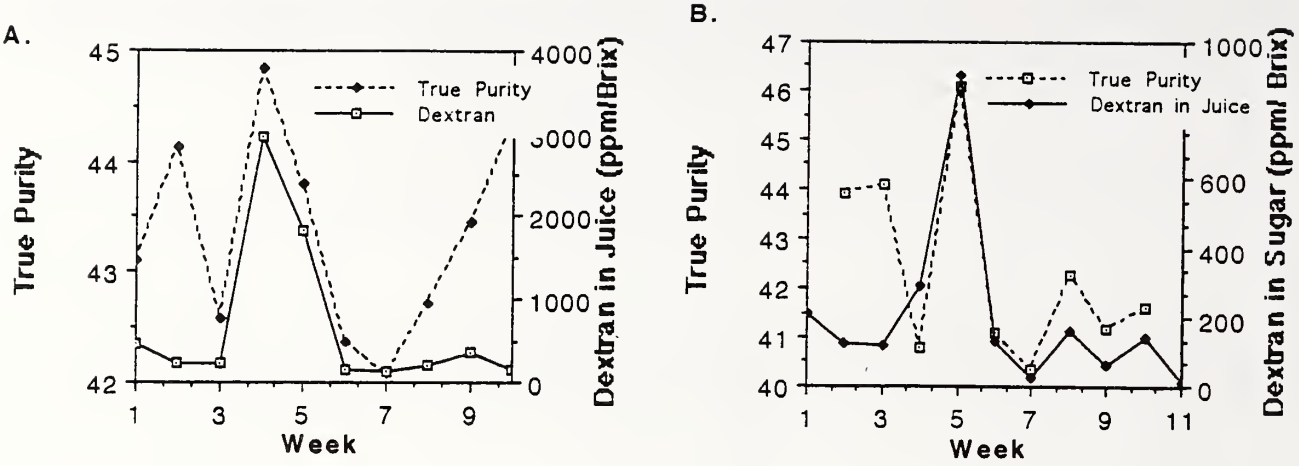

Figure 2. Molasses true purity (dotted line) versus dextran in sugar (solid line) for 1991. Figure A gives the average values by week for the Louisiana industry. Figure B shows the results at a single (typical) raw mill.

Table 2. Factory Recovery from Dextran Shock

Region	n	recovery (weeks)	standard deviation	minimum	maximum
Lafouche	2	5.50	2.121	4	7
Miss	3	2.67	1.528	1	4
Teche	8	3.00	1.309	2	5
Louisiana	13	3.31	1.653	1	7

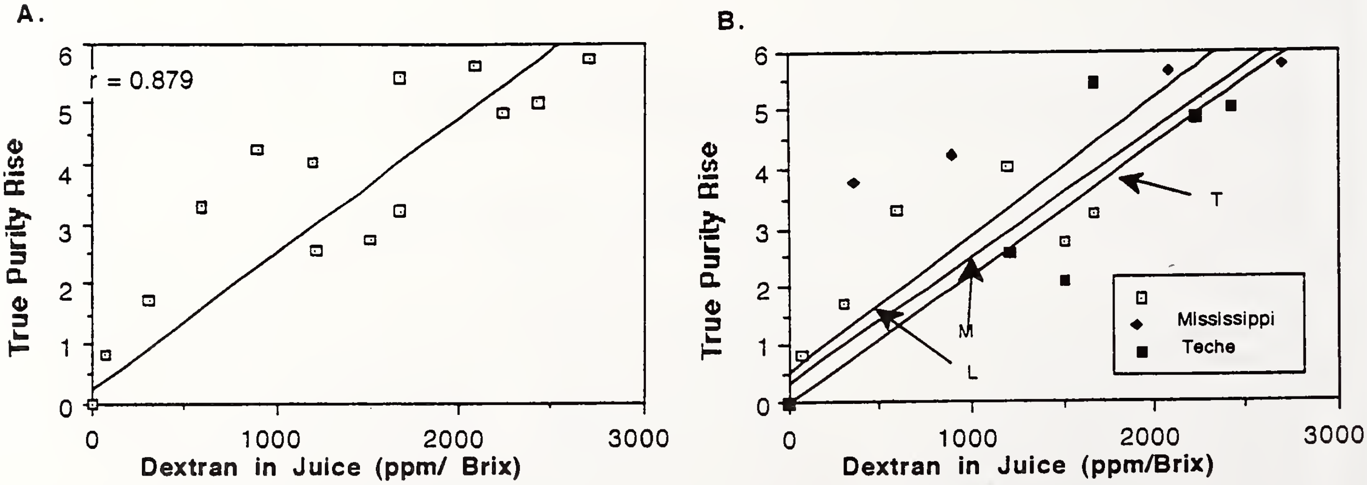

Figure 3. The relationship between dextran in juice and molasses purity rise in 1991. Figure A gives the values for the industry. The line shown is the statistical best-fit. Figure B shows the same information calculated by region, with the appropriate best-fit lines. The correlation coefficients by region are Teche (0.90), Lafourche (0.76) and the Mississippi (0.81).

A plot of the dextran in juice versus molasses true purity during peak dextran, harvest week 4, showed a direct correlation between the rise in molasses purity, determined as true purity minus the "practical target", and the dextran in the juice. The correlation coefficient (r) for the best fit line was 0.88 for the industry as a whole. When calculated by producing region they ranged from 0.76 to 0.90 (Figure 3). The change in molasses purity for each mill was calculated as the true purity minus the practical target for that mill. It is noteworthy that the values for purity rise ranges from 2.2 to 2.5 points per 1000 ppm of dextran in juice. This is just about half the value reported by Miller (7) for Australian massecuites. This difference may be either an artifact of the "practical target" approach or a reflection of greater efficiency in crystallization of commercial compared to laboratory crystallizers.

Given that a rise in final molasses purity of one point is equivalent to losing 1 pound of sugar to molasses for every ton of cane processed, it is obvious that a level of dextran that would not cause processing problems or even be noticed in the factory, can still produce a significant loss of sugar to molasses. For example a 6000 ton a day mill with a juice containing 250 ppm on Brix would lose 3750 lbs of recoverable sugar a day to the molasses. The mills in Louisiana average dextran levels greater then 250 ppm in juice for 40% of their season, and 15% of the time the concentrations are greater than 750 ppm dextran in juice (2). The scope of the problem is evident. The estimated value to Louisiana in recoverable sugar lost in 1991 due to dextran is over 3 million dollars. This is over the above any specific costs incurred due to processing problems or sugar penalties. These figures reinforce the need to minimize dextran brought into the factories by improving cane freshness.

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A SIMPLE ASSAY FOR STARCH IN SUGAR MILL PROCESS STREAMS

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ABSTRACT

Because of interference by background color the analysis for starch in sugar factory process streams: juices, syrups, and molasses is not a routine procedure. To overcome this problem analyses normally involve prior separation of the starch from the crude sample. An alternate protocol has been developed that does not require this physical separation. Starch is removed with amylase from half of a split sample and this portion is used to correct for background color. This analysis appears to be reliable and is less complicated than existing methods.

INTRODUCTION

All methods for analysis of starch in sugar streams face two problems, background color and choice of a suitable standard. Starches from natural products vary in their proportions of amylose to amylo-pectin (1). In sugar-cane, the ratio of amylose to amylopectin is approximately 1:4 (1). This affects the analysis because starch-iodine reacts differently with amylose or amylopectin. The choice of the standard thus determines the accuracy of the analysis (2). A standard must be soluble and representative of the material being analyzed. Cane-starch is not readily available for use as a standard, therefore, any analytical procedure relying on an external standard will, of necessity, produce an approximation rather than an accurate measure of the starch present.

Over the years, several methods for starch analyses have been introduced to the sugar industry (2, 3, 4). They were developed primarily to monitor starch concentrations in raw sugar and generally require prior separation of the starch from the sample. Several "quick" methods have been proposed (5,6) for sugars. There is one report of a "quick" test for starch in juices (7). This procedure, rather than precipitating the polysaccharides, uses extensive dilution to minimize background color. In all the reported methods, a starch iodine reaction is used for quantitation but the "standard starch" varies.

We have developed an alternative method for routine starch analysis that approaches the background color problem in a different manner. Half of each sample is treated with amylase to remove starch present, and then the treated portion is used to correct the analysis for background color. This method can be used by sugar factory laboratories to monitor the levels of incoming starch in juices and syrups. It is not designed to provide a definitive measure for the concentration of starch present in a sample, but rather to provide a simple procedure for comparative analysis of starch concentrations in raw sugar factory process streams.

MATERIALS AND METHODS

EQUIPMENT

Microcentrifuge
Analytical Balance
Water Bath
Spectrophotometer
Pipettes. Capacity to pipette 0.10 ml to 2.50 ml

MATERIALS

a-amylase (E.C. 3.2.1.1. Sigma Chemical Co., St. Louis Mo., A-0273) 10mg/ml in water
Starch : soluble potato starch (Sigma Chemical Co.,S-2004)

REAGENTS

2N Acetic acid: 120 g of Glacial Acetic Acid in 1000 ml of water
10% Potassium iodide solution in water. Prepared daily
M/600 Potassium iodate: 0.03567 gms dissolved in 100 ml of water, prepared weekly.

SAMPLE PREPARATION

Juice: Use as is
Syrup: 1 part syrup dissolved in 5 parts of water by weight
Sugar: 15 gms of sugar dissolved in 100 ml of water
Molasses: 6 gms of molasses dissolved in 100 ml of water.

RESULTS AND DISCUSSION

Standard Curve

Several starches were tested for use as a standard for this procedure. The standard starch had to produce a clear solution in water and be readily available. A potato starch from the Sigma Chemical Co (St. Louis, Mo. # 2004) was finally selected. Dry weights were determined and standard stock solutions were produced. Starch solutions at concentrations from 50 to 500 ug/ml were prepared and assayed to produce the standard curve (Figure 1). The addition of the amylase resulted in a slight opalescence in the blanks, which was removed by centrifugation prior to spectrophotometry. The starch-iodine complex formed with potato starch produces a peak absorbance at 570 nm (Figure 2). This peak was chosen as the absorbance for analysis, with the understanding that, at this wavelength, the amount of starch (amylopectin) present was being underestimated by 16%.

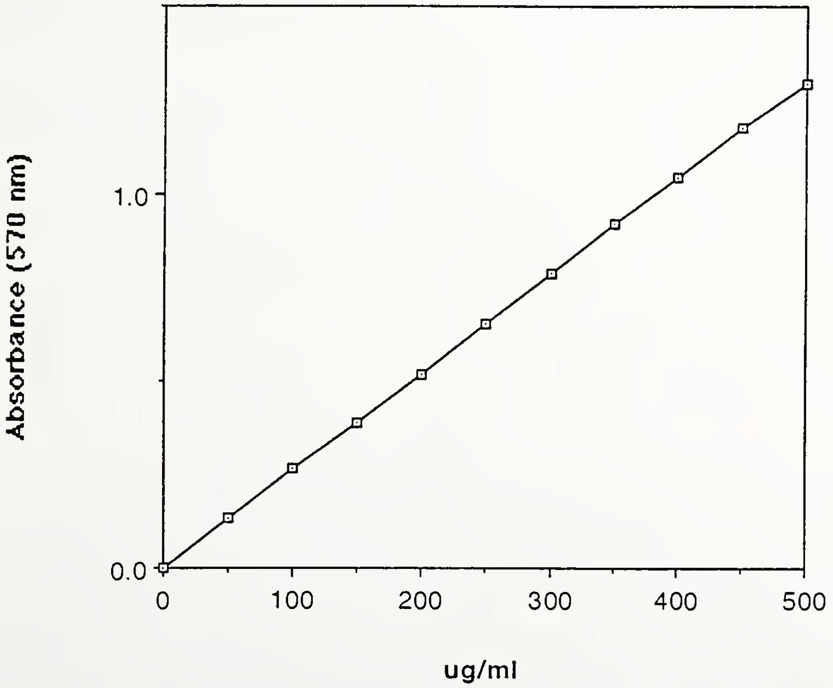

Figure 1. Standard curve, starch-iodine reaction using potato starch (Sigma S- 2004).

Procedure

First determine the Brix of the sample to be analyzed and then clarify by centrifugation. A table top centrifuge is suitable for clarification of all samples. Use the clarified sample for analysis. then, for each sample, pipette into each of two tubes, 1.0 ml of sample and 1.0 ml of water. One tube is the control and the other the test. To the control tube, add 0.1 ml of amylase (approximately 63 units) and to the test, add 0.1 ml of water. Incubate both tubes at 50°C for approximately one hour. Allow them to cool to room temperature (approximately 10 min.). Then add to each tube, mixing after each addition, 1.2 ml of 2N acetic acid, 0.25 ml of 10% potassium iodide solution and 2.5 ml of M/600 potassium iodate (KIO_3) solution. Centrifuge each tube at 2000 x G for 5 min to remove any precipitate that may form. Read the absorbance of the resultant supernates at 570 nm, using the control tube to set the zero absorbance on the spectrophotometer. The concentration of starch can be determined from a standard curve.

Amylose and amylopectin both produced different spectral peaks after starch-iodine reaction, with a peak at 635 nm for amylose and 530 nm for amylopectin (Figure 2). Wavelength scans on starch-iodine complexes formed with starch in molasses samples (Figure 3) produced peaks between 504 and 557 nm, with an average of 528 ± 11 nm. The variations in spectral peaks are probably due to differences in the amylose to amylopectin ratio of the starches present in the various samples. A precipitate was produced in the molasses, but not sugar samples upon addition of starch-iodine reagent. By spectral changes this precipitate has been tentatively identified as amylose. This would seem to indicate a differential precipitation of amylose out of molasses and may be a function of the higher calcium levels known to be present in some molasses.

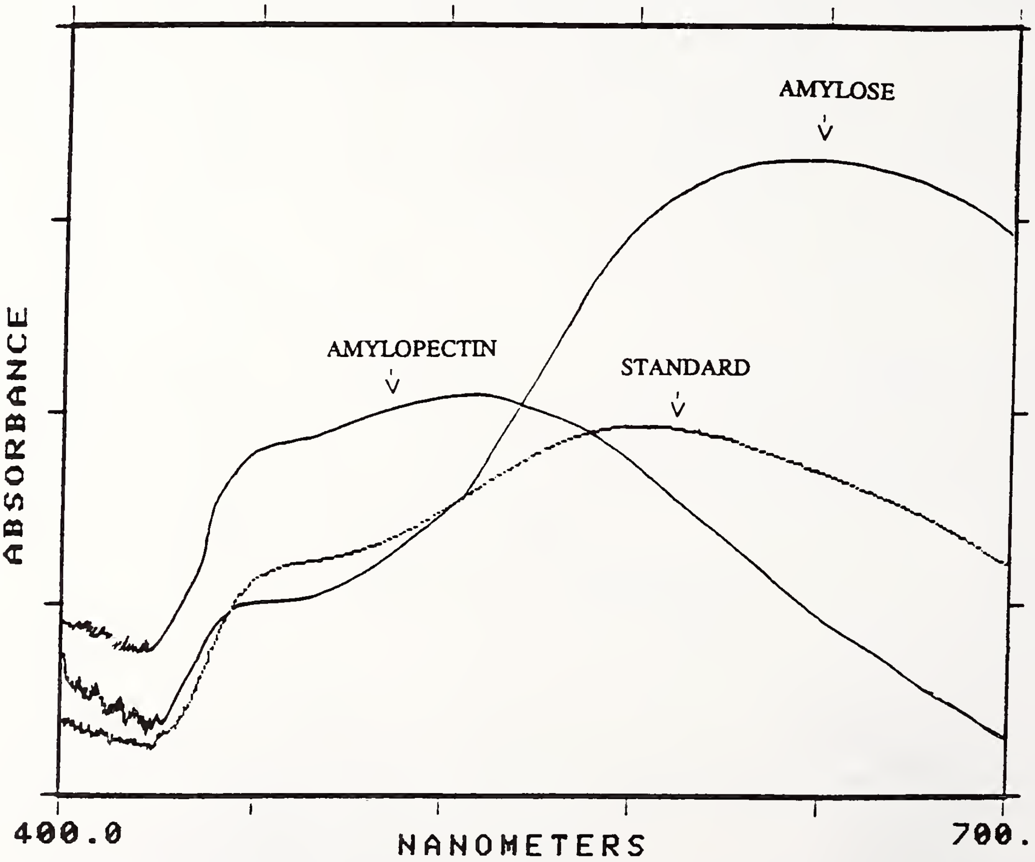

Figure 2. Wavelength scans of starch-iodine complexes formed with amylopectin, amylose and potato starch (Sigma S-2004).

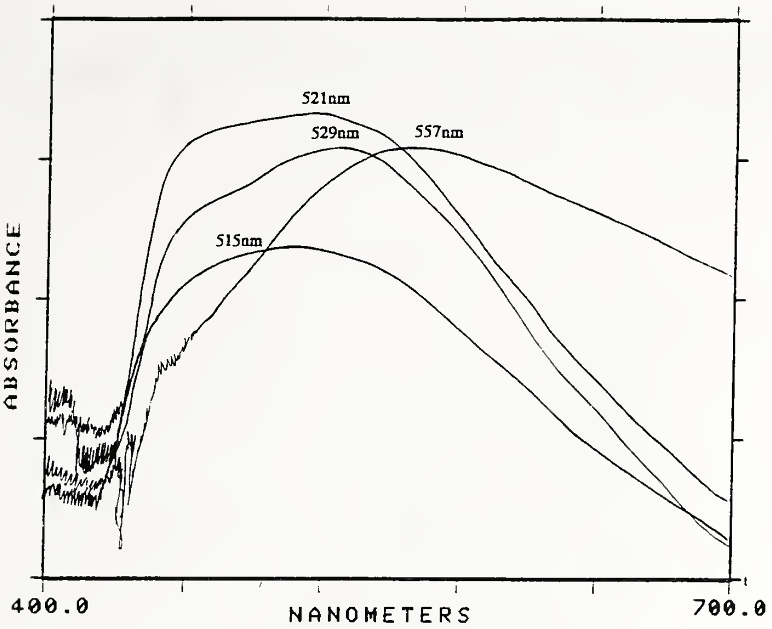

Figure 3. Wavelength scans of starch-iodine complexes formed with various Louisiana final molasses samples assayed using the amylase method of this report. The blank was the sample control as described in the text.

Typical Analyses

In order to determine the utility of the procedure, samples (n = 180) of molasses and sugar (n = 6) were analyzed using this method. A limited comparison of values for sugar are shown in Table 1. Two of the samples were analyzed at SPRI (courtesy of M. A. Godshall).

Table 1. Starch in Raw Sugar Samples.

Sample	Starch (ppm/Brix)	Starch (SPRI Method) (ppm/Brix)
Commercial Raw	250	305
Commercial Raw	202	374
Commercial Raw	209	
Commercial Raw	317	
Commercial Raw	477	
A sugar	183	

The reported values for starch using the new method were generally lower than the SPRI method. The difference can be accounted for by differences in standards.

Values for molasses ranged from 0 to 2800 ppm/Brix. Final molasses collected throughout the 1992 processing season in Louisiana from 18 different mills were analyzed for starch content using this method. The average values for the Louisiana industry shown by processing week (Figure 4) confirm the known decrease in starch as the sugar cane matures. Comparison of this procedure with other methods was not possible as molasses is not normally analyzed for starch. The new procedure appears to provide a good approximation of the starch present in sugar mill streams. It may provide useful information to the sugar mill operator that can be used to make operational process control decisions.

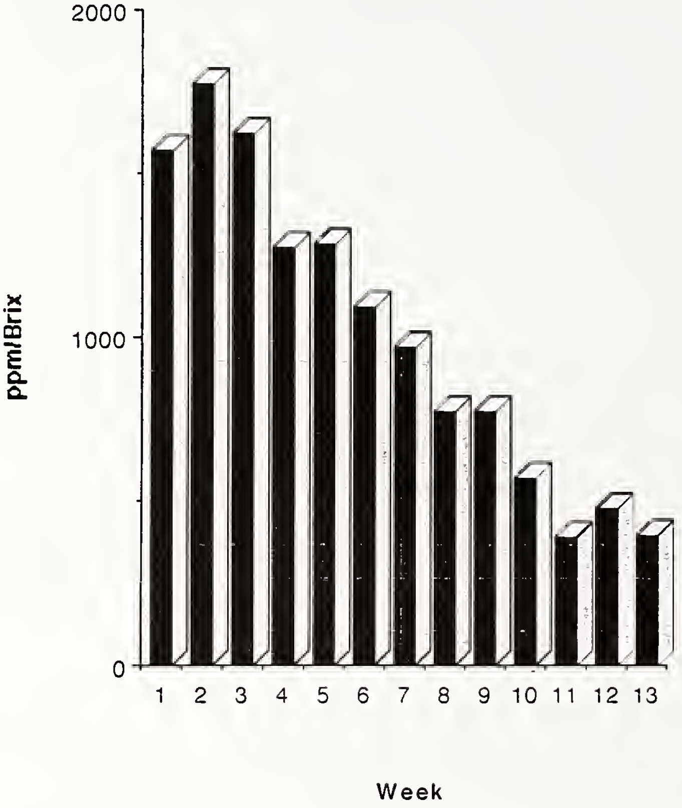

Figure 4. Average values for starch in Louisiana final molasses, by process week, for the 1992 sugar processing season.

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POSSIBLE SOLUTION TO DEXTRAN CONTROL

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ABSTRACT

Although the presence of dextran can have a devastating effect on the sugar mill profits, up to now no reliable method has been developed to completely restrain the activity of the *Leuconostoc mesenteroides* microorganism. Besides the reduction in sucrose recovery and the process problems, the sugar mills are also penalized by the refineries due to the high dextran content in the sugar delivered. These penalties some times represent several thousand dollars. The sugar mill have been utilizing bactericides together with mill sanitation, but in spite of high dosage, this treatment has not been adequate to control the dextran propagation. This paper describes an approach to limiting the effect of *Leuconostoc mesenteroides* in the mill by making changes in the liming system.

INTRODUCTION

The lack of an adequate control strategy has led to the conviction that a different approach to control the activity of this microorganism is needed. Lately, it has been suggested to use dextranase, but due to the high expense for the treatment in the range of $1.50 per ton of raw sugar produced (1), and the sensitivity of the product to temperature, pH, and brix prevailing in the process, and lack of FDA approval it has not been tried.

In this paper, a different method of solving this problem will be presented which is nothing new and is based on past experience of outstanding sugar technologists whose recommendations have been gathered from reports of these technologists and the experience at some sugar mills following similar procedures to the one being presented for your consideration. Also the results of preliminary laboratory trials and an installation at Sterling Sugars, Inc. will be discussed.

It is well-known that the microorganism *L. mesenteroides*, which is always present in soils, produces dextran when it comes in contact with sucrose. This occurs at the sugarcane fields, mostly in deteriorated cane resulting from conditions such as: hurricanes, freeze, flooding, etc., and also to cane left over in storage at the mill due to delays in grinding. Such cane can develop high levels of dextran before reaching the mill and also contaminate brings to the factory a high concentration of microorganisms that the extracted juice and develop immediately upon finding favorable conditions of pH and temperature.

According to Moroz (2), Chief Bacteriologist at Sucrest Crop., New York, "the optimum growth temperature appears to be between 21°C and 26°C while limits of growth are 5°C and 45°C. Optimum dextran yield occurs in the pH range of 7 to 8." Fulcher and Inkerman (3) report that the dextran synthesis at 35°C is 2 to 3 times the rate at 45°, but synthesis is negligible at 60°. Also Mc Calip and Hall (2) observed that *Leuconostoc* destruction of sucrose was retarded at low pH's (4.00) and that if the acids were not neutralized, no further activity of the organism takes place. Geerlings (2) had also mentioned earlier (1909) that the *Leuconostoc* organism possessed very little activity in neutral or acid solutions and he advised heating pre-limed juice up to 100°C for a few minutes should the juices be infested with the microorganism. Also the general observation is that *Leuconostoc* infection is minimized by heating raw juice before liming; it is inactivated at 43°C and destroyed by heat.

There are some sugar mills outside this country which have followed, to some extent, the recommended control of temperature and pH and did not experience problems with the propagation of dextran. For example, the Java method of double liming and heating (2) and the Davies fractional liming and double heating system (1) have in some cases decreased the tendency toward dextran formation. Also at a mill in Cuba (2), where the juice pH was increased to between 6 and 7 and heated to 70°C and then brought up to a pH of 8.5, very little slime growth occurred in the liming tanks, which are critical areas for the organism development.

FACTORY AND LABORATORY RESULTS

The above facts have led us to make some preliminary trials at the laboratory and factory of Sterling Sugars, Inc.

At this sugar mill, prior to 1989, we were having great problems in the process and the pan floor with the dextran present in the material processed, and high penalties, sometimes thousands of dollars were paid. For the year 1989, a heating coil was installed at the liming tanks to heat the juice with condensate from the limed juice heaters. The temperature of the water fluctuated from 88°C to 110°C, depending on the vapors used. The heating coil has an approximate heating surface of 350 sq. ft. This installation raised the temperature of the juice beyond the optimum growth temperature for dextran development (Figure 1).

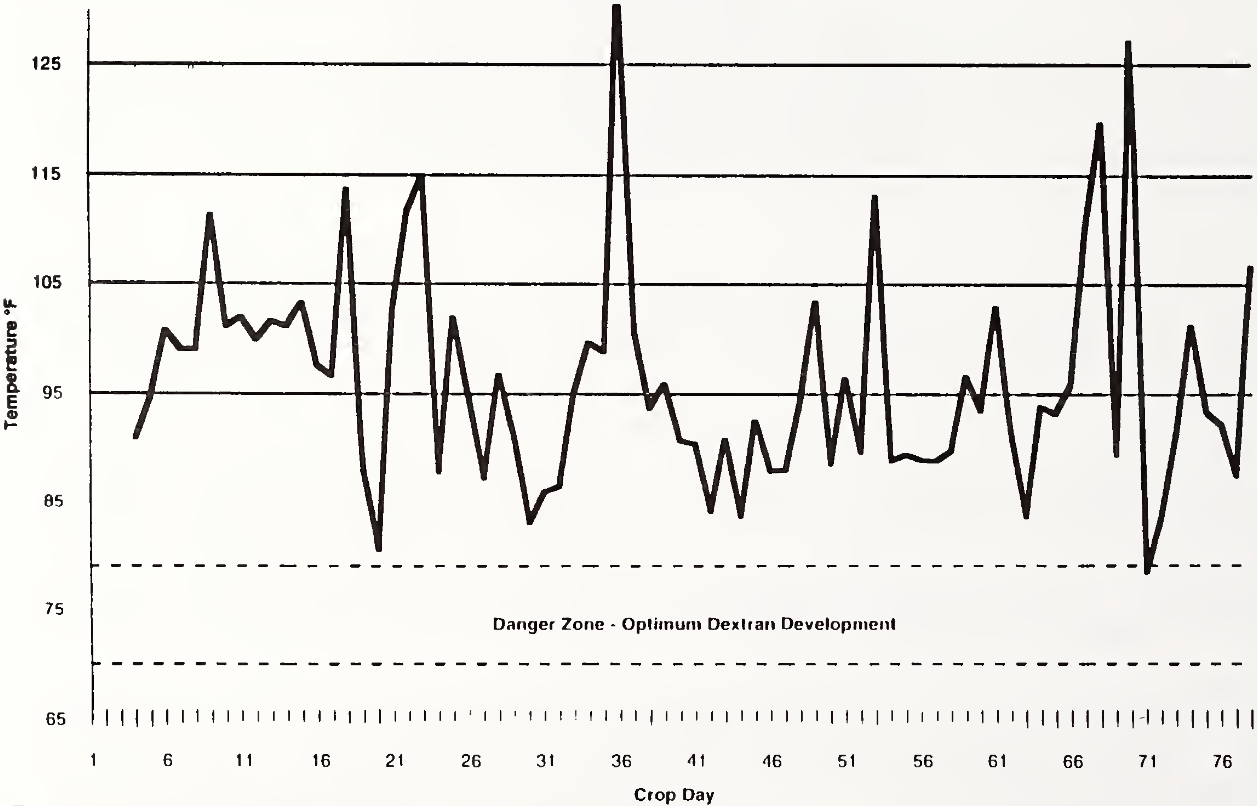

Figure 1. Juice temperature.

Table 1. Barges of Sugar Penalyzed for 1988 to 1991.

1988		1988		1990		1991	
Barge #	MAU	Barge#	MAU	Barge #	MAU	Barge #	MAU
665	287.5	240	297	202	620.5	81435	275
362	287.5	505	296	203	305.5	81279	739

Since the installation of this coil, the penalties on raw sugar have been reduced from 11 barges penalized in 1988 to only 2 barges per crop during the following three crops and to no penalty in 1992 (Table 1), despite worse weather due to Hurricane Andrew and a rainy season of 18.71 inches of water (Figure 2 & Figure 3).

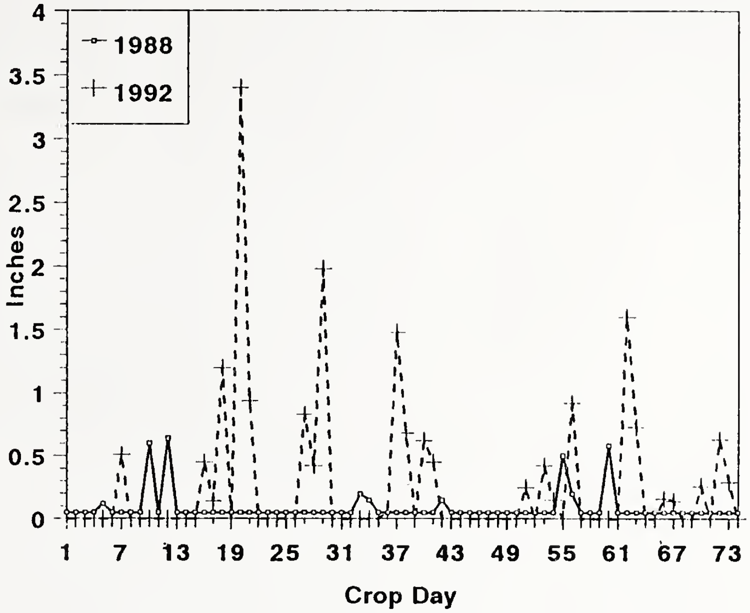

Figure 2. Rainfall in inches of water.

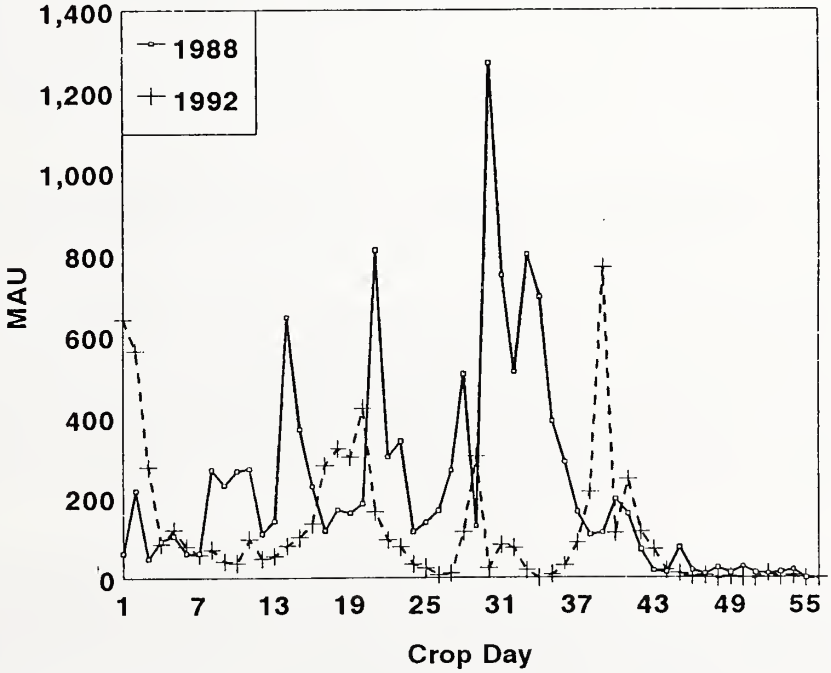

Figure 3. Raw sugar dextran - MAU.

Last year, some trails on contaminated juices were made at the laboratory. The pH and dextran were determined on the cold juices, and juices heated to 65°C and 75°C. There was an observed drop of 50% in dextran when heated to 65°C and 75°C, the analysis did not show any presence of dextran. There was an insignificant drop in pH. Due to lack of personnel the reducing sugars were not determined (Table 2).

Table 2. Preliminary Laboratory Trials on Contaminated Juices.

DATE	Cold			Heated					
	Trial Temperature 20-21°C			150°F			170°F		
	Number	pH	ppm	pH	ppm	% Drop	pH	ppm	% Drop
20-Dec	1	--	105	--	88	16.19	--	0	100
	2	--	176	--	116	34.09	--	0	100
	3	--	145	--	92	36.55	--	0	100
	7	--	65	--	40	38.46	--	0	100
	5	--	215	--	137	36.28	--	0	100
	6	--	183	--	110	39.89	--	0	100
	7	--	130	--	67	48.46	--	0	100
26-Dec	1	5.6	156	5.5	65	58.33	5.4	0	100
	2	5.5	90	5.3	24	73.33	5.3	0	100
	3	5.4	115	5.3	42	63.48	5.4	0	100
	4	5.6	88	5.5	48	45.45	5.5	0	100
	5	5.4	195	5.3	88	54.87	5.4	0	100
	6	5.5	183	5.3	68	62.84	5.3	0	100

OUTLINE OF RECOMMENDED DEXTRAN CONTROL PROCESS

We may be causing problems by liming the juice before heating and creating a favorable environment for dextran activity. Following this reasoning it is advisable that the present liming system (cold liming) be modified.

Based on results previously mentioned, the following dextran control system is recommended (Figure 4):

1. To continue to the present practice of mill sanitation.
2. To continue adding bactericide to the juice at the mill.
3. To heat the incoming mill juice before liming to a temperature of 70°C.
4. To lime the juice to a pH of 7.6.
5. To heat the limed juice to 103°C.

The cold juice can be heated at the mill juice tank by increasing its capacity and installing a coil with a temperature controller and also another coil at the liming tank; or, splitting the limed juice heaters into two sets: one for heating the cold juice and the other set for heating the limed juice (Figure 4). The first system, that of the coils, is simpler and has the following advantages:

1. No change to the actual juice flow installation will be required.
2. The imbibition water will be cooled as recommended.
3. Savings in steam.
4. Increase in limed juice heater capacity.

If no destruction of sucrose occurs, as it is expected, the addition of bactericide can be reduced to the amount required to keep the mill free of slime.

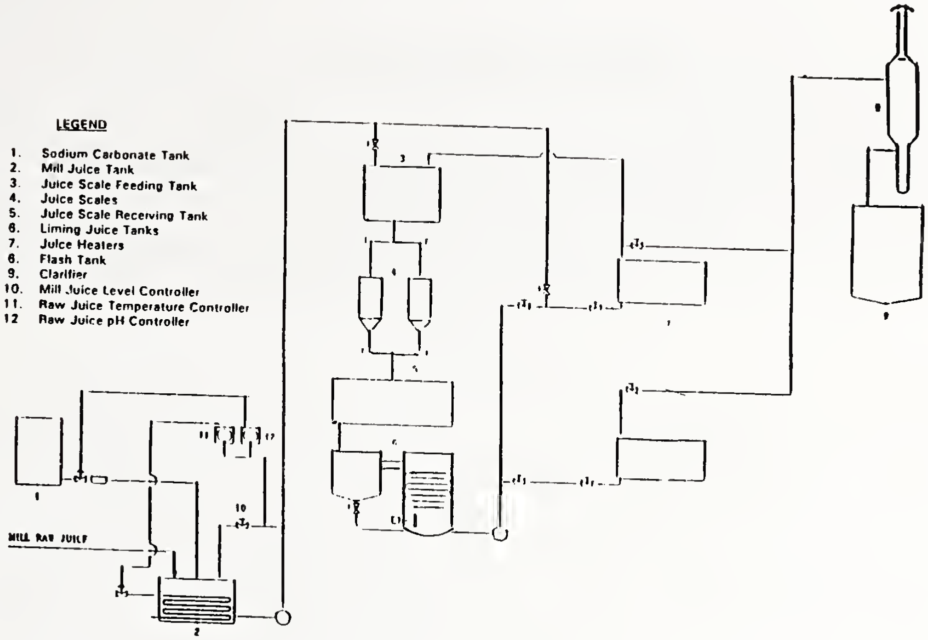
LEGEND
1. Sodium Carbonate Tank
2. Mill Juice Tank
3. Juice Scale Feeding Tank
4. Juice Scales
5. Juice Scale Receiving Tank
6. Liming Juice Tanks
7. Juice Heaters
8. Flash Tank
9. Clarifier
10. Mill Juice Level Controller
11. Raw Juice Temperature Controller
12 Raw Juice pH Controller
MILL RAW JUICE

Figure 4. Dextran control system.

On the contrary, if a destruction of sucrose is observed, which is not expected to happen, then other changes in the process will have to be made. There are two alternatives:

1. Bring down the temperature of the cold juice to 55°C, the lowest temperature at which good floc formation will be obtained. At this level there should be no sucrose destruction unless the pH of the juice is extremely low, or

2. Bring up, with soda ash (sodium carbonate), the pH of the cold juice to 6.1 before heating.

COMMENTS

The modified liming system has several potential advantages of the conventional cold liming system. This approach should reduce dextran formation in the mixed and limed juice tanks at the mill before the juice is heated. Reduction in dextran should result in less viscous liquors, better pol accounting and higher sugar recovery. Other possible advantages are reduction in the quantity of lime required with better control of pH and a more constant pH change through the clarifiers (4). Better clarification has been reported with increased settling rates, lower clarified juice turbidity, increased elimination of some colloids including silica (5). Reduction in mud volume with higher mud density and reduction of scaling of heat transfer surfaces may also occur. The overall effect would be improved sugar quality and recovery at reduced cost.

CONCLUSION

All these factors justify a trial be given to this system. The investment will be minimal. Any actual installation can be modified to be operated either way: cold liming or hot liming, as shown in the (Figure 4) presented. At some mills none or very little equipment will be required, only relocation of existing piping and possible the installation of a pump of a higher head and some tanks and control instruments.

ACKNOWLEDGEMENTS

The author wants to express his gratitude to Mr. Fred Y. Clark, President and Chief Executive Officer and to Mr. John H. Marcel, Vice-President and Plant Manager of Sterling Sugars, Inc. for their encouragement and support in the presentation of this paper and to the American Society of Sugarcane Technologists for their authorization to present it. Also the cooperation of Mr. Adam Barrilleaux, EICS Superintendent, and Mr. Terrence Marcel, in preparation of this script is appreciated.

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AGRICULTURAL ABSTRACTS

Soil Amendments for Sugarcane Production on Acidic Sandy Soils

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Continued expansion of the Florida sugarcane (interspecific hybrids of *Saccharum* spp.) production area will necessitate increased production on sandy mineral soils of central southern Florida. The objective of our research was to evaluate sugarcane yield response to soil amendments applied for increasing the soil pH of acidic sandy soils. The soil amendments studied permitted evaluation of the individual benefits to sugarcane productivity of neutralizing soil acidity, supplying nutrient Ca, and supplying nutrient Mg. Experiments were conducted on a Myakka sand (Sandy, siliceous, hyperthermic Aeric Haplaquods), which is characterized by clay and organic matter contents both less than 2%, and an Immokalee sand (Sandy, siliceous, hyperthermic Arenic Haplaquods), which is characterized by 1 to 5% clay content and less than 2% organic matter. At both locations, the experiment design was a randomized complete block with four replications. Each replication was a factorial of three soil amendments and four application rates. The soil amendments were commercial agricultural limestone ($CaCO_4H_2O$). Limestone and dolomite amendments were both applied at rates of 0, 1.1, 2.2, and 4.4 t ha^{-1}. Gypsum amendments rates (0, 1.9, 3.8, and 7.9 t ha^{-1}) were selected in order to apply an approximately equivalent quantity of amendment Ca as was applied by the limestone amendments. Our research confirmed that dolomite is the preferred liming amendment due to its capacity to supply nutritional Mg. Nutritional Ca supply from these soils appeared to be adequate. Our research also defined a threshold of pH = 5.5, above which liming did not improve sugarcane yield but below which a yield response to liming is expected. Surface soil pH was increased 0.24 pH units per tonne of limestone or dolomite applied. Existing recommendations should be refined to incorporate this new knowledge.

Antheral Transformation into Stigma in Interspecific and Intergeneric Hybrids of Saccharum

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The transformation of anthers or anther primordia into antheral stigmas or non-antheral stigmas was found in some Fl hybrids from *S. spontaneum* x commercial cultivar, and *S. spontaneum x Erianthus* spp. and some of their BC_1 and F_2 plants. The anther-or anther-primordia-transformed stigmas could be morphologically classified into antheral form (stigma with an incomplete anther at its base) and non-antheral form (stigma with a "carpel" at its base rather than an anther). More than 1 stigma often developed from a single anther primordium site, resulting in multiple stigmas as many as 12 within one spikelet in some clones. The antheral transformation may be associated with the inheritance of sex determination, on which the cytoplasm of female parent might play a significant role. Besides the antheral transformation, other variations of floral organs also were found.

These variations, independently or in combination with each other, influenced pollination and seed-setting and could be an obstacle to conducting interspecific and intergeneric hybridization for broadening the genetic base of sugarcane.

An Analysis of the Efficiency of Sugarcane Farms in Louisiana

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The efficiency of selected sugarcane farm-firms in Louisiana was evaluated. Using a panel data of forty-five firms, firm specific technical and allocative inefficiencies were estimated via alternative model specifications. Statistical results revealed that the technical efficiency of each firm has increased over the years. No correlation was found between farm-size and efficiency. Allocative inefficiency was found much higher than technical inefficiency. Also, fertilizer is being used over-optimally causing a high degree of allocative inefficiency. A frontier index was derived to estimate cost inefficiency from the cost function. Comparison between frontier and observed indices revealed that increase in efficiency will contribute significantly to firm profitability. However, large firms in general have higher advantages than smaller firms with our without inefficiency. This supports the hypothesis that the disappearance of small sugarcane firms in Louisiana is not due to lower efficiency, but due to lower income generating capacity.

Fallow and Successive Planting of Sugarcane in Florida

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Florida sugarcane growers now plant more of their sugarcane acreage under a successive rather than a fallow planting system. In their fallow system, they leave land idle, or grow a crop other than sugarcane, for about one year between sugarcane crops. In the successive system, they replant with sugarcane from 2 weeks to 3 months after a final-ratoon sugarcane harvest. From 1987 to 1992, successive planting increased from 44 to 69% of the Florida plant-crop acreage. The major objective of this research was to quantify plant and ratoon-crop yield differences between fallow and successive planting. We also sought to determine if cultivars responded differently to the two planting systems, and if the later planting dates of successive planting compared to fallow planting affected yields. Four field experiments planted from 1987 through 1990 comprised this study. Each experiment had from four to six cultivars. We obtained yield information for one experiment from the plant through the second-ratoon crops, and for another experiment in the plant and first-ratoon crops. We harvested the remaining two experiments only in the plant crop. Cane planted in the successive system yielded 14.1 tons of cane per acre (TCA) less in the plant crop than cane planted on fallow land. Plant-crop cane yielded 4.0 TCA less for fallow cane planted the same time as successive cane compared to fallow cane planted earlier at the normal time. Thus, other factors not studied accounted for 10.1 TCA or 71.6% of the plant-crop yield differences between the two planting systems. First-ratoon cane yields in successively planted fields averaged 6.7 TCA less than in fallow fields. In the second-ratoon crop, cane yields after successive planting averaged 1.5 TCA less than those after fallow planting.

Cultivars showed different responses to planting systems within each location, but no cultivar had a consistent response across locations. Planting earlier may increase yields in successively planted sugarcane.

Influence of Short-Term Flooding Following Planting on the Plant-Cane Yields of Four Sugarcane Cultivars

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In the Everglades Agricultural Area of Florida, sugarcane is normally planted during the months of October through January. Although this period coincides with south Florida's dry season, rainfall events exceeding 5-cm are not uncommon. Due primarily to imposed drainage restrictions with regard to water quality and the area's lessening soil depth, sugarcane fields frequently remain saturated for several days to several weeks following such rainfall events. A field experiment was conducted to investigate the impact of such conditions on the yield components of several different cultivars.

Four cultivars planted on three different planting dates, each separated by 18-day intervals, were subjected to either flooded or drained field conditions subsequent to planting. Flooded conditions were initiated four days after the last planting and were maintained for 10 days. The factorial experiments was planted in a split-split plot design with flooding as the main plot factor, planting date as the subplot factor, and cultivar as the sub-subplot factor with six replications of each treatment.

Saturated field conditions following planting had an overall negative influence, reducing cane yields by nearly 11 percent when averaged across planting dates and cultivars. Reductions in cane tonnage averaged 2.3, 21.6, and 8.9 percent in the first, second, and third planting, respectively. A significant flooding X planting date X cultivar interaction was observed, indicating a differential response by cultivars in various stages of germination to flooded conditions. With regard to cultivar, cane yields were reduced by 2.0, 2.3, 17.0, and 22.5 percent in cultivars CL73-239, CP 72-1210, CP 72-2086, and CP 80-1827, respectively. Flooding had a greater impact on stalk populations than on biomass, with reductions of 9.9 & 1.5 percent, respectively. In summary, results indicate that saturated field conditions following planting can have a significant negative impact. However, the magnitude of this impact is dependent upon both the timing of the flood and the cultivar planted.

Meiotic and Fertility Characteristics of Elite Sugarcane Clones

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Chromosome number and pairing of elite sugarcane (*Saccharum* spp. hybrids) has not been widely studied. Our objective was to describe the cytology and fertility of 21 elite clones used as recurrent parents at Houma, Louisiana (29.6° N). Meiotic analyses, anther rating, and pollen stainability were studied in 1990 to 1992. Seed yield data were from crossing records (1972 through 1991). Chromosome numbers ($2n = 99$ to 118) were typical of germplasm. Ten clones were chromosomal mosaics, and univalents and multivalents were found at low levels in all clones. All clones probably produced aneuploid gametes, but seed yield was not significantly affected by meiotic behavior. Five self-compatible clones yielded 107 to 138 seed/g when used in crosses, and 63 to 136 seed/g when selfed. Four self-incompatible male clones yielded 52 to 73 seed/g when used as males in crosses. Thus, self-fertility tended to increase as male fertility increased.

The data will be useful in predicting chromosome numbers of hybrid sugarcane progeny and in designing crosses.

Simulated Sugarcane Beetle Damage in Sugarcane as Influenced by Herbicide, Time of Tiller Removal and Removal Intensity

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The sugarcane beetle, *Euetheola humilis rugiceps* (LeConte) (Coleoptera: Scarabaeidae) is an occasional pest of sugarcane in Louisiana. Overwintering adult beetles emerge in the spring and are attracted to sugarcane fields. Adult beetles penetrate the soil along sugarcane rows, lay eggs and feed on below ground portions of young shoots. The amount of shoot destruction needed to cause economic damage is not known; however, if economic loss occurs it is generally thought to be in fields with weak/gappy stands. Factors that delay cane germination and tillering (i.e. herbicides) and crop age may also exacerbate sugarcane beetle damage and result in significant loss in cane yield. Field studies involving the variety 'CP 65-357' were conducted over a four year period to identify a level of shoot loss that would significantly reduce cane yields and factors that may contribute to economic damage. Sugarcane beetle damage representing four intensity levels of (0, 25, 50, and 75%) was simulated by removing shoots at three times during the spring (March, April, and May). In addition, three herbicide regimes (Metribuzin, Terbacil, and Fenac) were imposed. In two experiments shoots were removed in plant-cane crops and yields taken at the end of the subsequent plant-, first-, and second-ratoon growing season. Additionally, two experiments were conducted where shoots were removed in the first-ratoon crop and yields collected at the end of the first- and second-ratoon growing seasons.

Data indicated that all treatment combinations, excluding the 0% shoot removal level, could have a significant effect in reducing sugar yields, including TRS (theoretical recoverable sugar), tons cane per acre, and pounds of sugar per acre. The effect of tiller removal was also found in the subsequent crop year following shoot removal. Results from this study identified conditions that not only contributed to economic yield loss by sugarcane beetle but any cultural practice that may destroy developing shoots (i.e. false-shaving and rolling cultivators).

Abundance of White Grubs (Cleoptera: Scarabaeidae) in Florida Sugarcane by Soil Type

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Sugarcane fields in Florida on sandy or organic (muck) soils were sampled to determine the abundance of white grub species (Coleoptera: Scarabaeida). Adult flight activity was monitored with light traps and larval populations were estimated by soil samples. Both methods revealed similar patterns: more *Ligyrus subtropicus* (Blatchley) on muck, more *Phyllophaga latifrons* (LeConte) and *Anomala marginata* (F.) on sand. *Cyclocephala immaculata* Olivier were more evenly distributed over both soil types although they tended to favor sand. A practical implication of these results is that the most damaging species, *L. subtropicus* is rare or absent in sandy soils.

Varietal Adaptability to Mechanical Harvesting in Louisiana

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Data were collected for stalk brittleness, erectness, mechanical damage, and scrap (millable cane left in the field after harvest) from the plant-cane (1991) and first-stubble (1992) crops of seven commercial and one candidate varieties from a test designed to measure varietal adaptability to mechanical harvesting. To promote a more vigorous growth and therefore a greater propensity of the crop to lodge, a higher rate of nitrogen fertilizer was used (205 kg/ha). Stalk brittleness was determined by using a hand-held, stalk breaking device (SBD) that measures the deflection (mm of bend from the vertical plane) of the stalk before breakage occurs. Erectness or the degree of lodging was determined through a field rating (scale of 1 - 9 with 1 totally erect and 9 completely recumbent) prior to harvest. After cutting with a mechanical harvester, 50 stalks from each plot were checked for mechanical damage caused by the harvesting operation. The results showed that there were differences among varieties and crop years in all four parameters which have a direct bearing on adaptability to mechanical harvesting; however, differences among varieties and years for the four parameters were, undoubtedly, attributed to the effects of Hurricane Andrew in 1992. The varieties, CP 65-357, CP 72-370, and CP 74-383, with a history of good harvestability, were found less brittle, more erect, had less mechanical damage, and harvested well with little scrap in both years despite the hurricane. Further, the data showed that erectness ratings were highly correlated with scrap ($r = 0.61^{**}$) over the two years of the study, and could be used as a reliable estimate to gauge varietal adaptability to mechanical harvesting.

Sugarcane Disease, Dry Top Rot and Purple Spot (Red Leaf Spot), Present in Florida

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Dry top rot was first observed at the Sugarcane Field Station in November, 1991. Symptoms include initial drying of the spindle leaf tips, subsequent drying out of the entire spindle, and finally death of individual stalks within a stool. Growth of the upper internodes of the stalk is reduced and the internodes gradually taper and desiccate. Eventually the top internodes just below the spindle leaves shrink and shrivel as if suffering from severe drought. Vascular bundles located at the base of the plant are pinkish in infected plants. Microscopic examination reveals large masses of brownish-orange spores, 17-25 in diameter, of the pathogen, *Ligniera vasculorum*, in the xylem. Water flow is restricted in infected plants.

A second disease, purple spot, which is also called red leaf spot, was found by Dr. Soto, a visiting plant breeder from Guatemala, in February, 1993 on several cultivars in Stage II at the Sugarcane Field Station. This is a minor foliar disease which is identified by an irregular roundish leaf spot that is a reddish-purple in color. Pseudothecia of the pathogen, *Dimeriella sacchari*, are usually present for microscopic verification. Variation in cultivar susceptibility to both diseases was noted.

Mon 13211 for Seedling Johnsongrass Control in Sugarcane

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Reports of herbicide resistance developing within weed populations are common. The occurrence of these herbicide-resistant populations is most prevalent where the same herbicide or family of herbicides is used repeatedly. The majority of the sugarcane fields in Louisiana are infested with johnsongrass. Currently, there are only four preemergence herbicides labelled for its control within the crop. Of these, trifluralin and pendimethalin belong to the same chemical family. The remaining two, metribuzin and terbacil, belong to different chemical families, but both have a common site of action in the photosystem II electron transport process of photosynthesis. When coupled to the fact that sugarcane is mono-cultured, there is a clear risk of developing herbicide resistant johnsongrass populations within these fields. To slow the development of these populations, new herbicides having preemergence activity against seedling johnsongrass and representing diverse chemical families must be developed for sugarcane.

The evaluation of MON 13211 for the preemergence control of seedling johnsongrass within sugarcane began in Louisiana in 1991. When applied at rates ranging from 0.3 to 2.2 kg ai/ha, MON 13211 provided excellent (>90%) control of seedling johnsongrass with no sugarcane injury. The level of johnsongrass control with MON 13211 at 0.3 and 0.6 kg/ha was equivalent to standard applications of metribuzin at 2.6 kg/ha, terbacil at 2.1 kg/ha, and pendimethalin at 2.2 kg/ha. Broadleaf weed control with MON 13211 was unacceptable unless atrazine at 2.2 kg/ha was included in a tank mixture. Sugarcane yields were similar to the standards at all rates of MON 13211 when it was applied in tank mixture with atrazine.

If labelled, MON 13211 will give Louisiana sugarcane growers an additional herbicide representing a new family of chemistry for the preemergence control of seedling johnsongrass. This should slow the development of herbicide resistant johnsongrass populations. The risk of negatively impacting the environment following the use of MON 13211 would also be reduced because use rates would be significantly lower than currently labelled herbicides.

Methods of Preserving Female Tassels Used in Sugarcane Crosses

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The objective of this group of experiments was to compare methods of preserving tassels used in crossing sugarcane. The five treatments studies were airlayers, CP-acid solution, Brazil-acid solution, and two combinations of CP and Brazil solution and airlayers. Experiments were set up with males or polycrosses isolated in cubicles. Each cubicle contained female tassels from the same clone (grown under the same conditions) maintained in each of the different treatments to minimize differences except for method of tassel preservation. Males or polycrosses were used as replications because we had insufficient tassels to replicate under each male. The CP-acid solution is prepared by; combining commercially prepared sulfurous and phosphoric acid solutions and adding 12 ml/gal to high quality water obtained by treatment with a reverse osmosis system. The Brazil-acid solution was prepared starting with sulfur dioxide gas, phosphoric acid, sulfuric acid, and nitric acid. Airlayered stalks were prepared by enclosing 2 nodes in wet sphagnum moss for root development. Experiment 1 had 11 female and 4 male clones. There were no significant differences in seed set per gram of fuzz among acid treatments. In experiment 2, there were 13 female and 6 male clones used and again there were no significant differences in seed set among acid treatments. In experiment 3, there were 12 female and 5 male clones and there were no differences in seed set among acid treatments. However, in experiment 3 we had 4 clones with airlayered tassels and they produced significantly higher seed set than any of the acid treatments. In experiment 4, pollen availability was significantly reduced, therefore, overall seed set was reduced in this experiment. Although the CP-acid solution produced higher seed set in experiment 4, based on the overall data we have decided to utilize the Brazil sulfurous acid solution in the Canal Point crossing program because its cost is about 0.1 of the commercially prepared sulfurous acid solution we are currently using. Airlayering female tassels is the most expensive way to maintain female tassels, but it is still the best as average seed set per tassel of 1,684 airlayered tassels was 418.8 compared to 236.6 for 2,533 acid maintained tassels in the 1992-93 crossing season. Total seed production at Canal Point for the 1992-93 crossing season was 1.36 million.

Observations of Leaf Scald in Louisiana Sugarcane

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The initial observation in Louisiana of leaf scald, a potential serious disease of sugarcane, caused by *Xanthomonas albilineans* was made in two clones of the second line (clonal) trials in November 1992 at Houma, Louisiana. Additionally, a commercial variety, CP 74-383, included as a control in the second clonal trials, was also found to be infected. Symptoms included chlorosis and necrotic lesions on leaves, side shoots, resulting from germination of lateral buds, and reddening of vascular bundles. The characteristic white, pencil-line streaks were noted primarily on the leaves of the young side shoots. Further examination of the other clones in the second-clonal trials at Houma, as well as clones in the first clonal trials near Mathews, Louisiana, revealed an additional eight experimental clones with leaf scald symptoms. Leaf scald was also observed at two commercial locations in the regrowth of variety LCP 82-89 following the fall harvest. Additional distribution studies between late November 1992 and April 1993 were limited by frosts and freezes which destroyed the sugarcane leaves. An extensive survey of leaf scald distribution is planned for April and May 1993.

Varieties recommended for commercial planting in Louisiana, candidate varieties of the 85-89 series, and selected parental clones will be tested for susceptibility to leaf scald in both Louisiana and Florida in 1993. Stalks of 52 clones for this study were cut from nurseries in Louisiana. Approximately 60 buds of each were germinated in the greenhouse for transplanting to the field in the spring. These plants will be inoculated in early summer using a modified decapitation method. However, in collecting bud sets for these 52 clones, the white, pencil-line symptom was observed in one to 14 plants from 22 of the clones indicating prior natural infection. With the exception of 11 varieties, the same varieties were harvested and planted for a duplicate test in Florida. In the seedcane nurseries, symptoms of leaf scald were observed in stalks of seven of the varieties.

Although the presence of leaf scald in Louisiana was first documented in 1992, the level of systemic infection and the distribution thus observed indicate that the disease has been in Louisiana for some time. Further, symptoms indicative of aerial spread were observed among infected plants suggesting that Hurricane Andrew with its 140mph winds may have contributed to the aerial distribution of the pathogen and the expression of symptoms.

Cotesia flavipes Parasitizing Sugarcane Borer Larvae Infesting Young Sugarcane

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Cotesia was released in Florida in 1963 against the sugarcane borer (SCB). It is now considered our most important parasitoid of the SCB, parasitizing from 40 to 60 percent of SCB larvae from late summer to harvest. Its presence is usually hard to detect during winter months; however, populations normally increase during July. The purpose of this study was to determine if *Cotesia* could effectively parasitize SCB larvae infesting young plants about 61 cm high (2 ft), in a laboratory test. *Cotesia* parasitized all SCB larvae collected. Therefore, I propose that *Cotesia* could be increased in the laboratory, and released annually in the spring to augment field populations. This should increase its utility as a biopesticide, minimize the build-up of damaging SCB populations, and reduce the use of pesticides. In places like Louisiana, where *Cotesia* does not survive the winter, annual releases would be necessary.

Influence of Stubble Longevity Practices on the Yield of Sugarcane Grown on Fine-Textured Soil

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Plots of CP 72-370, established on a Baldwin silty clay loam using both Kleentek^R and field-run seed sources, were evaluated for response to post-harvest soil cover of stubble and the soil applied pesticides, carbofuran (Furadan^R) and metalaxyl (Ridomil^R). The primary objective of this study was to evaluate stubble performance and longevity on poorly drained clayey soil. All possible combinations of treatments were tested in plant, first, second and third stubble cane (virtually all field-run plots were devoid of millable stalks by third stubble and were not harvested). As an average of stubble crops in the cane cycle, Kleentek^R cane produced more sugar/ha ($P<.01$) and more millable stalks/ha ($P<.01$) but slightly inferior juice quality ($P<.01$ for sucrose, CRS and Brix) and stalk weight ($P<.05$) than field-run cane. A disparity in Ratoon Stunting Disease infection level partially accounted for the vigor and yield advantage of Kleentek^R cane.

The spring applications of carbofuran at the rate of 11.2 kg/ha of formulated material produced unremarkable results. Metalaxyl, applied at the rate of 1.7 L/ha of formulated material in liquid nitrogen fertilizer each spring, depressed sugar/ha in plant cane ($P<.05$) and cane/ha in second stubble ($P<.05$). Metalaxyl controls the Pythium spp. most implicated in feeder root necrosis, but this species was not dominant when the site was assayed during first stubble growth.

Post-harvest soil cover of stubble resulted in erratic yields. Stubble covering increased first stubble cane yield ($P<.01$) after the severe cold of December 1989, but decreased cane yield ($P<.01$) in third stubble. This was the only meaningful interaction among treatments variables involving a reversal in mean ranking.

Reduced Soil Insecticide Use in Sugarcane Planted After Rice

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Soil Insect data and yield data were obtained from 10 Florida sugarcane fields planted after rice production. Soil insecticides were used at planting for wireworm control except in 12 rows per field which were planted without insecticides. Within each field, one pair of plots was sampled for soil insect populations. Each plot was 20 x 20 meters in size. One plot was selected in an area of the field with soil insecticide and the other plot in an adjacent area without soil insecticide.

Yield data were obtained by two methods. First, stalks per acre were obtained in the summer be counting stalks in six 100 foot sections of row in each area of insecticide application and each area of no insecticide application in each field. Second, stalk weight was obtained in the spring before harvest by weighing four 25 stalk bundles of cane in each area of insecticide application and each area of no insecticide application in each field.

The following data were obtained from these fields from November, 1990 to April 1993. Only one wireworm was found in 100 soil samples (50 insecticide and 50 non-insecticide) taken when sugarcane fields were planted. Since flooding is known to kill wireworms, the extremely low wireworm population present at this time was probably due to the previous flooding of the fields for rice production. There were no significant differences in wireworm populations between insecticide applied and insecticide free areas at 0, 5, 10, or 15 months after planting. Also, there was no significant difference in stalks per acre, weight per stalk, or estimated tons of cane per acre between insecticide applied and insecticide free areas.

In summary, both insect data and yield data indicate that in many cases soil insecticides for wireworm control are not necessary when planting sugarcane after rice.

This research has been supported by the Florida Sugar Cane League and Western Palm Beach County Farm Bureau.

Sugar Yield Increases Needed to Justify Subsurface Drainage Installation Costs in Louisiana

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The relatively flat, low lying land in south Louisiana requires artificial drainage to grow sugarcane. Currently, drainage is provided by a network of surface drainage ditches which occupy considerable areas of land. This network of ditches provides adequate surface drainage for the most part, however ditches are too far apart and too shallow to provide adequate soil profile drainage. Subsurface drains, which are widely used in the high-yielding farm areas of the U.S., provide soil profile drainage without removing land from crop production: farming is done above the drains.

Experiments conducted since the mid 1960's have shown that subsurface drainage in south Louisiana not only increases cane and sugar yields but also increases stubble longevity. Louisiana sugarcane growers have been reluctant, however, to install subsurface drainage primarily because of the high initial cost and, in some cases, the necessity of a sump and pump as a subsurface drainage outlet.

In this study, costs of installing 13 different subsurface drainage systems (drain spacings ranging from 18 to 160 feet) in Louisiana were determined. Costs also included loan interest, assuming that the land owner would obtain a loan at 10 percent interest to pay for installing subsurface drains and that repayment would be made annually for 10 years (the actual life of a drainage system should exceed 20 years). The total costs of subsurface drainage systems were determined by summing the costs of subsurface drainage materials, drain installation, sump, and loan interest. The annual payment, which was 10 percent of the total cost, ranged from $214/A for drains spaced 18 feet apart to $40/A for drains spaced 160 feet apart.

Field experiments were conducted in south Louisiana during 1974-1990 to determine cane and sugar yield responses to subsurface drainage. The value of the yield increases from subsurface drained areas was determined by multiplying the average annual yield increase in lbs/A by $0.132 (owner/operator's share of the price of raw sugar, $0.22/lb, after paying milling costs). The value of average sugar yield increases ranged form zero to $124/A. To justify drain installation costs, the value of the average yield increase in eight sugar crops must be sufficient to make ten annual payments because three crops of cane are normally grown in four years and eight crops are grown in 10 years.

The cost of installing subsurface, drainage was justified for Commerce silt loam with 80-ft drain spacing and for Jeanerette silty clay loam with 90-ft and 135-ft drain spacing. The cost of installing subsurface drainage was not justified on Baldwin silty clay and Sharkey clay. The values of improved machine trafficability and increased stubble longevity, both of which are benefits of subsurface drainage, were not considered in justifying drain installation costs in this study.

Johnsongrass (Sorghum halepense) Control and Sugarcane (Saccharum sp.) Response to Time of Asulox Application

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In a field study conducted in 1992, Asulox at 3.34 lb ai/A was applied POST to sugarcane cultivars CP 70-321, CP 72-370, and LCP 82-89 infested with johnsongrass. Applications were made on April 15, May 1, May 15, and June 15, and an untreated check was included for comparison. A split plot experimental design replicated five times with whole plots as cultivars and subplots as application times was used.

Johnsongrass control on July 15 for individual Asulox application times was similar regardless of cultivar. Averaged across cultivars, johnsongrass control was 79 and 84% for May 15 and June 15 applications, respectively, which was higher than for April 15 and May 1.

Johnsongrass reinfestation occurred following the earlier Asulox applications. Averaged across cultivars, johnsongrass panicle counts were lowest for the June 15 application and were lower for the other application times when compared with the untreated check. Johnsongrass panicle counts, averaged across application times, were greatest in CP 70-321 and were related to the higher counts for the April 15 and May 1 applications.

The June 15 application of Asulox caused severe visual sugarcane injury consisting of leaf chlorosis and necrosis, and was highest for CP 72-370 and lowest for CP 70-321. When Asulox was applied in April and May, total sugarcane yield and stalk population, averaged across cultivars, were similar. Sugarcane yield and stalk population were lower than earlier applications for the June 15 application, but greater than for the untreated check. Averaged across Asulox application times, stalk population was highest for LCP 820-89 and similar for CP 70-321 and CP 72-370.

Delaying Asulox application until June 15 reduced johnsongrass panicle production compared with earlier applications, but increased sugarcane injury particularly with CP 72-370. Sugarcane stalk population, sugarcane yield, and sugar yield were highest when asulam was applied May 15 or earlier.

Assessment of Sugarcane Crop Damage by Hurricane Andrew

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On August 25 and 26, 1992, Hurricane Andrew, packing sustained winds of 140 MPH with gust exceeding 160 MPH crossed the Louisiana coastline between Terrebonne and St. Mary Parishes. The 'Eye' of the storm passed approximately 30 miles to the west of Houma sparing the immediate area with the most destructive winds; however, it was estimated that winds in excess of 100 MPH pelted the area for more than four hours. Its initial northwesterly and later northerly course brought hurricane force winds over most of the 20 sugarcane growing parishes of the State. The immediate reaction by the press was complete destruction of the entire Louisiana sugarcane crop. After conducting field surveys on August 26, 27, and 28, personnel of the United States Department of Agriculture (Agricultural Research Service and Agricultural Stabilization and Conservation Service), Louisiana State University Agricultural Center (Louisiana Agricultural Experiment Station and Louisiana Cooperative Extension Service), Production Credit Association, and the American Sugar Cane League met on August 28 to discuss the extent of the damage and to formulate a plan of action for sugarcane growers and processors to follow to minimize their losses. An assessment was made parish-by-parish with the predicted losses ranging from a low of 10 percent in the fringe areas of the hurricane's path to over 50 percent in the area of the eye of the storm. The weighted average loss for the State was set at 25 percent. Other topics discussed included planting and harvesting recommendations to include the use of chemical ripeners.

Prior to harvest, another meeting was called on September 14 by the Audubon Sugar Institute and attended by representatives of most of the State's raw sugar mills and refineries. Topics of discussion included cane delivery, cane quality, milling losses and throughput, clarification and filtration, boiling house operations with emphasis on anticipated lower syrup purities and increased dextran and starch concentrations in factory streams, and boiler operations as a result of the storm.

Hurricane Andrew caused an estimated $78.8 million in direct monetary losses (assuming a price of sugar at $0.46 per kilogram) to the sugarcane growers, processors, and landlords in Louisiana at the first processing level. This does not take into consideration the increase in cost to plant and harvest hurricane damaged sugarcane.

MANUFACTURING ABSTRACTS

The Procedure to Maintain a Constant Level of Sugar Cane in a Donnelly Chute

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As more and more sugar mills install Donnelly Chutes to feed their mills, there is a definite benefit from controlling the level of sugar cane in the Donnelly Chutes in order to increase the grinding capacity and maximize efficiency of the mills.

This paper will present the different types of equipment required, how the equipment works and the benefits from installing an automatic level control system for the Donnelly Chutes.

Automatic Mill Feed Controller at Caldwell Sugars Co-op

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Updated technology in electronic equipment has become more available to the sugar industry. Being able to control a uniform matt of cane entering the crusher, thus providing better mill performance has been a problem in the past.

Installing a PID (Proportional Integral and Derivative) single loop digital controller has insured us of a stable and even feed into our mill. As a result of using this controller we can gain in the mills acceptance of the feed and better extraction of the juice.

Performance of Flangeless Mill Top Rolls at Cajun Sugar Cooperative, New Iberia, Louisiana

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St. Augustine, Florida

The concept of flangeless mill top rolls originally was developed at the Tongatt Sugar Factory, South Africa, in 1972 by J.A.P. Jacquelin. The arrangement consists of the replacement of the top roll flanges for stationary flanges, fabricated of heavy steel plates, bolted onto the mill housings.

In 1990, all the mill top roll flanges were replaced for stationary flanges after the mill tandem had been converted to the four-roll mill design, fitted with drag type intermediate carriers and vertical Donnelly chutes. The decision to install the stationary flanges was made to solve problems of mill chocks caused by bagasse jamming between the cheek-plates and the ends of the mill feed roll. The changes were made at Cajun Sugar Co-op after the experience with stationary flanges were observed at Central La Pastora in Venezuela. This sugar factory grinds approximately 1 million metric tons per crop and has used the stationary flanges very successfully for many years.

Increasing Mill Throughput at M.A. Patout & Son, Inc.

Willard E. Legendre
M.A. Patout & Son, Inc.
Jeanerette, Louisiana

In the past, the Louisiana sugar industry has been complacent with their grinding rates. The sugar cane supply was just enough to keep most of the mills and farmers in the black due to low operating costs. Each mill's cane supply was not enough to justify any type of major expansion programs, and with higher operating costs, some of the smaller mills had to close. This left extra cane for the remaining mills to grind. Time is coming around again where operating costs are higher than some of the existing smaller mills can afford because of lack of cane supply.

An aggressive and progressive approach to acquire a larger cane supply, M.A. Patout & Son, Inc. can justify a major expansion program. With a short Louisiana crop, higher grinding rates have to be achieved. Patout has and is still improving their grinding rate by incorporating three major improvements on the mill, Donnelly chutes, a shedder, and roller preparation.

Applying Basic Management Principles in the Sugar Mill

Eduardo Samour
P.E., Asst. Chief Engineer
Sugar Cane Growers Cooperative of Florida
South Bay, Florida

In the light of the present economic situation, and the international trade agreements, the sugar industry faces new challenges.

To stay afloat, and compete with foreign sugar producers, we have to become more efficient and productive.

Mill engineers concentrate their efforts in the mill operation, achieving new records in grinding rates and striving to reduce losses in the process to a minimum, but often forget that one of the most important tasks they have is to manage the resources available to them, and to control costs.

This paper describes basic management principles, and their application in the sugar mill. Specific examples are given and practical suggestions made that will help better understand the role of the engineer as a manager.

Utilizing Ion Transport Studies to Optimize Boiler Chemical Treatment Programs

Douglas G. Brown
W.R. Grace Dearborn Division
Lake Zurich, Illinois

The transportation of common scale forming impurities through the aqueous feedwater-boilerwater cycle may be used as a predictive indicator of boiler treatment effectiveness. Detailed analyses of impurities in composite feedwater and boilerwater samples for a South Florida Sugar Mill, allowed for quantitative comparisons of various chemical treatment program designs during actual boiler operation.

Glyphosate-Induced Changes in the Composition of Sugarcane: Effects of Tops on Processing

B.L. Legendre, USDA-ARS
Sugarcane Research Unit
Houma, Louisiana

M.A. Clarke and M.A. Godshall
Sugar Processing Research Institute
New Orleans, Louisiana

The plant growth regulator glyphosate (N-phosphonomethyl glycine) was labelled for sugarcane in Louisiana and Florida in 1980 as a foliar spray to hasten maturity and extend the period of high sucrose levels of stubble (regrowth) cane only. However, as early as 1983 there was concern that glyphosate also increased the level of polysaccharide, notably dextran, in juice of harvested cane. In preliminary studies conducted in 1985 and 1986, no association was found between the use of glyphosate for increasing sucrose content and the level of dextran in the juice of treated cane. Further, the data indicated that dextran levels (ppm on solids) of the juice were not influenced by removal of the leaves above the apical meristem of the cane with or without glyphosate. Field studies were repeated in 1992 in stubble cane of three sugarcane cultivars (CP 65-357, CP 70-321, and CP 72-370) to study the effects of glyphosate and five topping heights (no removal of tops and 5 cm above and 10, 25, and 40 cm below the apical meristem) on the composition of sugarcane juice. Factors studied which could have an effect on processing included sucrose and purity percent cane, theoretical recoverable sugar (TRS) per ton of cane, fiber percent cane, invert and inorganic ash percent juice, total polysaccharide, dextran, starch, and leucoanthocyanin pigments.

The study revealed that glyphosate increased sucrose percentage cane and TRS per ton of cane regardless of cultivar but had no effect on purity percentage cane. Both sucrose and purity percentage cane increased with topping or without glyphosate. Glyphosate lowered fiber percentage cane regardless of cultivar while fiber percentage cane differed among cultivar. However, fiber percentage cane remained constant once the portion 5 cm above the apical meristem was removed.

ISSCT Workshop on Purification Systems in Cane Processing

Stephen J. Clarke, Audubon Sugar Institute
LSU, Baton Rouge, Louisiana

Michael Hylton
Sugar Industry Research Institute
Jamaica

This workshop was held in Jamaica in March/April 1993 and dealt with all aspects of factory operation between the extraction plant and the crystallization stage. Much discussion took place on the application of best available technology for clarification and filtration as related to the quality of raw sugar. Conditions appropriate to the application of me sophisticated clarification systems were discussed in detail, along with a description of beet sugar purification systems. The workshop ended with consideration of new technologies for the industry, including ion-exchange, ion-exclusion and membrane systems.

The paper will outline the activities and conclusions of the workshop.

Possible Solution to Dextran Control

Gilberto Cacho
Sterling Sugars, Inc.
Franklin, Louisiana

The sugar refineries have been penalizing all raw sugars high in dextran. This penalty sometimes represents several thousand dollars and in some instances, it has gone to over a hundred thousand dollars at some mills. Yet, at present, no solution has been found efficient enough to eliminate completely the presence of the microorganism in the raw sugar. The sugar mills have been using bactericides, together with mill sanitation, but this treatment has not been adequate to control the dextran propagation. Lately, it has been suggested to use dextranase, but due to high cost of the treatment, in the range of $1.50 per ton of raw sugar, and the sensitivity of the product available to the temperature, pH, and brix prevailing in this process, it has not been tried.

Hence, based on past experience of well known sugar technologists, I am suggesting a modification to the cold liming process which should control the dextran propagation at the sugar factories. Its effectiveness has been observed at sugar mills, outside of this country, which have installed it. Also, trials carried on at the laboratory and factory of Sterling Sugars, Inc. have confirmed its effectiveness.

The modification to be made at the factory is simple and will not involve a high investment; probably, at some sugar mills, no extra equipment will be needed, only some extra pipes. The installation to be made is explained and illustrated on a diagram presented.

Viscosity Effects in the Lubrication of Large Sugar Mill Journal Bearings

S.W. Granger and I.E. Adams
Texaco, Inc., R&D
Port Arthur, Texas

One of the most important elements of the mill are the massive rollers, that extract the cane juice from the fibre, and the bearings that support the rollers. The proper operation of these rollers and shafts greatly depends on adequate lubrication. A field test was undertaken to determine the lubrication requirements of the large journal bearings associated with the mill rollers.

The field test was conducted at a sugar mill over a period of approximately four weeks during the 1992-93 season. Two mills from the tandem were selected and instrumented to monitor their operation. The following parameters were monitored: Operating temperatures of the bagasse and cane journal bearings; the lubricant flow rates to each of four bearings; the cooling water temperatures of each of the bagasse bearings, along with the speed of the bagasse rollers.

Synthetic, mineral, semi-synthetic and vegetable oils were tested. The range of viscosities studied was between 680 centistokes to 6800 centistokes at 40 degrees Centigrade. The lubricant flow rates were from about 160 pints per day bearing to about 0.5 pints per day per bearing.

A discussion of the data collected and conclusions drawn from that data will be presented.

Starch Analysis in Syrup and Molasses

D. Sarkar and D.F. Day
Audubon Sugar Institute
Louisiana State University
Agricultural Experiment Station
Baton Rouge, Louisiana

Starch analysis in factory process syrups is not normally conducted because of difficulties involved in monitoring color changes due to indigenous color in the samples. A methodology was developed for starch analysis as part of a program monitoring polysaccharides in process streams in sugar factories. Starch analysis, normally requires separation of the starch from the molasses by alcohol precipitation, in order to separate this polymer from other colored materials. Then analysis involves some form of the starch iodine reaction. Our protocol does not require prior separation of the starch from the sample, rather a split sample is used, starch is removed from the control tube with amylase. The control is used to correct for color. A starch iodine reaction is used to quantitate the starch in the material.

This analysis appears to be reliable and is considerable faster and less complicated than existing methods.

Why use Continuous Diffusion of Sugarcane

P.D. Cheape
Silver-Weibull, Waikoloa, Hawaii

An extraction of 97 percent can be obtained from a cane diffuser when the cane is properly prepared. A draft (diffusion juice percent prepared cane) of 100 percent can be expected. Cane diffusion is best described as the displacement of the sugar rich juice from the fiber by a counter current flow of water and fiber-juice in which the water flows as an advancing front. These basic designs of diffusers are in operation today. They are BMA, DeSmet and the Silver-Weibull ring. A short description of each is presented.

Advantages and Benefits of Hydraulic Drives for Tandem Mills

Lou Wendel
Flender Corporation
Marietta, Georgia

Traditional steam powered sugar mill drives, though robust in design, suffer from many deficiencies such as poor efficiency, intense maintenance and limited torque control. Hydrostatic drives on the other hand possess the necessary characteristics for a reliable sugar mill drive.

This article will take the reader through the evolution of mill drives, discuss the operation and benefits of modern hydrostatic transmissions and present a systematic approach for the successful application of hydrostatic drives on sugarcane grinding mills.

Of increasing application is the use of the fourth roll pressure feeder to the mills for increased through-put and greater extraction rates. However, the fourth roll can consume 10-12% of installed turbine horsepower.

The incorporation of a dedicated hydraulic drive for the pressure feeder will allow full turbine power to the mill rolls.

Mat Thickness for Maximum Mill Capacity

Luis R. Zarraluqui
Sugar Cane Growers Cooperative of Florida
Belle Glade, Florida

Mill capacity depends, among several factors, on the thickness of the cane mat being fed to it. Along with roll length, roll peripheral velocity, and mat weight per unit volume, mat thickness is one of the four factors determining mill tonnage.

With the other three factors established, a necessary condition for maximum mill tonnage can be mathematically found to be: $M = 1/2C$, where M is matt thickness for maximum tonnage, and C is roll center distance, both dimensions in the same units. Such relation applies to pairs of rolls, and is valid for either the top and fourth rolls of a 4-roll mill, or to the top and front rolls of any mill, whether of the 3-roll or 4-roll type.

For mat thickness shallower than M, mill tonnage will be proportionately lower; on the other hand, should attempts be made to increase the mat above the maximum capacity thickness, crowding of the mill would inevitably ensue.

The derivation of the relation, and a discussion of the effect on tonnage of a sound selection of the mat thickness, vis-a-vis the help offered by some forced feeding devices are presented.

The Louisiana Cane Sampling System - The Effect of Mud on Cane Payment and on Factory Operations

Harold Birkett and Buckley Kessler
F.C. Schaffer and Assoc., Inc.
Baton Rouge, Louisiana

The Louisiana core sampling system of direct cane analysis is described. Data on the accuracy and reproducibility of the system are presented. The rationale for employing the sediment test is given together with the effect that the sediment test has on cane payments.

The effect that mud in cane deliveries has on factory operations is also described.

The Production of a New Panelboard Product From Sugarcane Rind

Paul Friedman,
SugarTree Technology
Boulder, Colorado

Sugarcane has been a largely unprofitable worldwide industry in need of fundamental technological innovation to transform its basic cost and income structure. With the use of separation technology, sugarcane becomes the source for high-valued-added co-products including hardwood, oriented strandboard, medium density fiberboard, wax, chemicals, animal feed and a new panelboard product produced from the sugar cane rind.

The separation system technology preserves the full potential of each component of the cane stalk since it produces individual streams of juice-containing inner core, tough fibrous structural material, and thin outer waxy layer. This separation allows each steam to be further processed into both sugar and new sugarcane co-products by exploiting their unique characteristics. The juice-containing inner core has been separated from the primary source of contamination, allowing for a much purer juice stream. The de-juiced inner core can be processed into various fiber products including medium density fiberboard. The fibrous material maintains its wood-like structural characteristics since the rind does not pass through conventional cane crushers; thus, it can be used to manufacture several structural wood composite products.

Ultrapanel™ is a proprietary, low-density structural board product. The fibrous rind segments (about 1 1/2 - 2 1/2 inches wide, 12 inches long and 1/32 inch thick), with the outer waxy layer removed, are cut into 1/4 inch wide strands. These strands are then dried to 10-15% moisture content and a mixture of resins, biocides and fire retardants is applied. The coated rind strands are then formed into a mat which is fed to a 4 foot wide, continuous press. The product is cut into 8-9 foot panels which are then rehumidified and stored for sale.

Several unique building systems for low-cost housing and other facilities have been created. One thousand tons of cane provide enough Ultrapanel™ to construct over 20 houses, each with a living area of 700 ft^2.

Textiles and Geotextiles from Sugar Cane

Dr. John R. Collier
Chemical Engineering Department

Dr. Billie J. Collier
School of Human Ecology
Louisiana State University
Baton Rouge, Louisiana

A process for directional delignification of sugar cane rind, under development at LSU, is demonstrating the ability to obtain fiber bundles that can be converted into textile and geotextile products. A key requirement is obtaining fiber bundle having sufficient length for mat formation and yarn spinning. A Tilby pilot scale process is currently being used in this research to obtain rind segments that are cut to desired bundle length. Directional delignification is accomplished using a low concentration alkali solution while undergoing appropriate mechanical action; this can be coupled with steam explosion of the treated rind. Current applications being pursued include biodegradable geotextile mats for erosion control, and yarns spun from these bundles.

AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS
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Nature of papers to be published:

Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

Frequency of publication:

The Journal will appear at least once a year. At the direction of the Joint Executive Committee, the Journal may appear more frequently. Contributed papers not presented at a meeting may be reviewed, edited, and published if the editorial criteria are met.

Editorial Committee:

The Editorial Committee shall be composed of the managing editor, technical editor for the Agricultural Section and technical editor for the Processing Section.

The Editorial Committee shall regulate the Journal content and assure its quality. They are charged with the authority necessary to achieve these goals. The Editorial Committee shall determine broad policy. Each editor will serve for three years; he may at the Joint Executive Committee's discretion, serve beyond the expiration of his term.

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The technical editor receives from the managing editor all papers whose subject matter falls in his "area." He obtains at least two reviews for each paper from qualified persons. The identities of reviewers must not be revealed to each other nor to the author during the review process. Instructions sent with the papers emphasize the necessity for promptness as well as thoroughness in making the review. Page charges will be assessed for the entire manuscript for non-members. Members will be assessed for those pages in excess of ten (10) double spaced pica typed pages of 8 1/2" x 11" dimension with one (1) inch margins.

When a paper is returned by a reviewer, the technical editor evaluates the paper and the recommendations of the reviewers. If the paper as received is recommended by two reviewers for publication in the Journal, it is sent to the managing editor.

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RULES FOR PREPARING PAPERS TO BE PRINTED IN THE JOURNAL OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

Format

Unless the nature of the manuscript prevents, it should include the following sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION, CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized. Scientific names shall be italicized.

All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. Exactness in reproduction can be insured if electronic copies of the final versions of manuscripts are submitted. Potential authors are encouraged to contact the managing editor for specifics regarding software and formatting software to achieve ease of electronic transfer.

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Name of the author(s), institution or organization with which he is associated, and the location should follow the title of the paper.

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The abstract should be placed at the beginning of the manuscript, immediately following the author's name, organization and location.

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Number the tables consecutively and refer to them in the text as Table 1, Table 2, etc. Each table must have a heading or caption. Capitalize only the initial word and proper names in table headings. Headings and text of tables should be single spaced. Use TAB function rather than SPACE BAR to separate columns of a table. Each table should be on a separate sheet.

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Number the figures consecutively and refer to them in the text as Figure 1, Figure 2, etc. Each figure must have a legend. Figures must be of sufficient quality to reproduce legibly.

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Format Example

EVALUATION OF SUGARCANE CHARACTERISTICS FOR MECHANICAL HARVESTING IN FLORIDA

J.E. Clayton and B.R. Eiland
Agricultural Engineers, SEA, USDA, Belle Glade, Florida

J.D. Miller and P. Tai
Research Geneticists, SEA, USDA, and Canal Point, Florida

ABSTRACT

INTRODUCTION

MATERIALS AND METHODS

RESULTS

Table 1. Varietal characteristics of nine varieties of sugarcane over three-year period at Belle Glade, Florida.

Figure 1. Relative size of membrane pores.

DISCUSSION

CONCLUSIONS

ACKNOWLEDGMENTS

REFERENCES

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Alignment: Original alignment is important in that it affects the efficiency of editing Word Perfect and other word processing files. The greatest flexibility for font changes is achieved when the document is full justified. Procedure: Select Format (Shift-F8); select Line (option 1); Select Justification (option 3), select Full (option 4).

The use of SPACE BAR for alignment results in a most inflexible structure. As a general rule SPACE BAR should only be used for space between words and limited other uses. If the space bar is used to indent paragraphs, align and indent columns, or create tables the alignment does not hold upon font change.

Do not use hard returns at the end of sentences within a paragraph. Hard returns are to be used when ending paragraphs or producing a short line.

Consider placing tables and figures within the text as you wish them to appear. This will save considerable editing time and effort and reduce the possibility of placement error.

Styles: ***Italicize*** the scientific names using one of the following procedures:

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1. Smith, I. M., H. P. Jones, C. W. Doe, 1991. The use of multidiscipline approaches to control rodent populations in plants. Journal of American Society of Plant Management. 10:383-394.

References: Official manuals are often difficult to understand. As a result, numerous help books are published. We have found Mastering WordPerfect 5.1 by Alan Simpson, ISBN 0-89588-670-7 easy to understand and follow. The features such as tables, style appearance, and alignment are well presented in the book.

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1994 OUTSTANDING PRESENTATION AWARDS

D.L. Anderson, J.D. Miller, G.H. Korndörfer, and J.M. Shine, Jr. Florida Sugarcane Production (1928-1994) and the Importance of Cultivar Development

Benjamin L. Legendre. Field Soil, Sediment Correction and Sugar Yield

F.A. Martin, K.P. Bischoff, and S. Milligan. LCP 86-454 - A New Sugarcane Variety for Louisiana

Saul Herscovici. High Horsepower Planetary Gear Boxes for Reduced Cost and Improved Efficiency in Sugarcane Mill Applications

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PRESIDENT'S MESSAGE
FLORIDA DIVISION

Armando Acosta
Talisman Sugar Corporation, Belle Glade, Florida

Good morning everyone. Thank you for coming.

I want to begin by welcoming each of you to the 24th Annual Joint Meeting of the American Society of Sugar Cane Technologists. A special welcome to members of the Louisiana Division, to my fellow members of the Florida Division and to our guests.

What better way to build friendships than getting to know each other in a relaxing and enjoyable atmosphere where there is time to chat informally about our interests? Please, take advantage of this meeting's opportunity to do just that.

On behalf of the men and women of the Florida Division, whom I represent here this morning, it is my pleasure to report to you the results of the last crop. The 1993-94 crop can be tagged as one of the best in the history of the Florida Sugar Cane Industry. First, a total of 175 days passed between the start of the first mill on October 14, 1993 and the stop of the last mill in the first week of April, 1994. On the field side, 15,800,000 gross tons of sugar cane were harvested over 445,000 acres, which yielded an average of 35.50 gross tons of cane and 3.90 short tons of sugar per acre. This lead to an overall production of 1,738,469 short tons of sugar 96° Pol and 99,252,385 gallons of final molasses 79.5° Brix.

Progress in our industry, like any competitive business, depends largely on technical changes. New developments are important in both the field and the factory. In this sense we are proud of the success and accomplishments realized in the Florida Sugar Cane Industry.

For example, mechanical harvesting continues to rise. In the 1993-94 crop, five of the seven mills ground 100% mechanically harvested cane. The other two were up to 50%. The preferred harvester is the single-row chopper type. A two-row chopper type, however, has run in the last 3-4 years, but to a lesser extent. We should mention that one mill developed and has been using a two-machine, infield storage harvesting system for about 19 years with great success.

Likewise, mechanical seed cutting is expanding fast in Florida. In this case, one company has cut seed with the chopper harvester for years, while other companies (and growers) have chosen the Louisiana type whole-stalk harvester. The latter, however, has difficulty cutting lodged, heavy canes, without causing damages.

More importantly as things are turning out, the adoption of mechanical harvesting and seed cutting technologies is bringing economic benefits. In harvesting, for instance, one advantage seen is a cut down in the time elapsed between burning, harvesting and grinding, which keeps the sucrose deterioration to a minimum.

We acknowledge that we are not in this alone and appreciate the cooperation of the manufacturers of agricultural machines. After all, our business is interdependent. To them, our thanks.

Another example of Florida's success is the sugar cane variety development program. This is a three-part cooperative research effort among: 1) The USDA/ARS Sugarcane Field Station at Canal Point, 2) the University of Florida, Institute of Food and Agricultural Sciences, Belle

Glade, and 3) the Florida Sugar Cane League, Inc., Clewiston. This effort has been decisive in keeping our industry on the competitive edge. The scientists involved engaged in producing varieties that are high yielding, disease-pest-and cold-resistant and now also adaptable to machine harvesting. Their contribution, working ethics, honesty, dedication and commitment, as a whole, is recognized.

On the factory side, new facilities for juice and syrup purification and the use of different pan boiling systems have contributed to a better molasses exhaustion and sugar quality. Today, our factories in general, and some in particular, rank high in extraction and grinding rates worldwide which provides maximum returns to the industry.

Constant improvement is the concept that should drive all of our actions. That is, improving quality, productivity, energy consumption, communication and in the end, lowering the cost of production.

Presently, we continue to face several challenges in both the field and the factory, namely: 1) Market competition, 2) health concerns, 3) environmental and ecosystem awareness and 4) even actions that threatened the existence of strong research oriented experimental stations and sugar factories established more than 30 years ago in this part of the country.

As our predecessors did in their days, we are taking these challenges of our days to set a stronger industry for the generations that will lead after us. So, in this context, we are accepting changes and taking risks. To change is normal. To take risks, is not. Nevertheless, if we study our industry's past record, I think you will agree that risk takers have always been around.

In closing, let me say that together we can accomplish great things - things more important and more meaningful than I have even outlined here this morning.

You, fellow members of our Society, will be the final source of those good ideas. You, will be the driving force that launches the future in the right direction.

Thank you for your attention.
Enjoy the meeting.

PRESIDENT'S MESSAGE
LOUISIANA DIVISION

REFLECTIONS ON THE LOUISIANA SUGAR CANE INDUSTRY CAN WE CONTINUE FOR ANOTHER 200 YEARS?

Edward P. Richard, Jr.
USDA, ARS, Sugarcane Research Unit, Houma, Louisiana

On behalf of the membership of the Louisiana Division of the American Society of Sugar Cane Technologists, I would like to express by sincere thanks to the Florida Division for hosting this the Twenty-Fourth Annual Joint Meeting at St. Petersburg Beach, Florida.

Louisiana's sugarcane growers began 1993 on an optimistic note. After all, the winter was mild, the crop was green and growing in February, and in the previous three years, the industry had been through a once in 100 year freeze, a once in 100 year period of excessive rainfall, and a category IV hurricane. Why wouldn't there be optimism - four bad years in a row - nah, never.

Then March 14 came and temperatures plummeted throughout the belt hitting 27 F as far south as the Sugarcane Research Unit at Houma. Gone was the lush green growth and the thoughts of layby cultivating the crop in April saving countless dollars in cultivation costs. Gone too was the optimism of a bumper crop. However, the Louisiana sugar industry, true to form, remained guardedly optimistic that the 1993 crop would be a profitable one.

As the 1993 growing season progressed, a significant portion of the industry was subjected to a summer drought that, in some instances, left areas of the belt without significant rainfall into early fall. The net effect of the mid March freeze and the summer drought was a crop which was short in stature and relatively immature at harvest time. The shortness of the stalks caused growers to use more cane for seed and thereby caused a greater than anticipated reduction in crop acreage available for milling.

The harvest season for some of the raw sugar factories began on October 1 and ended on January 1, 1994, when the Enterprise factory completed its grinding operation. Heavy rains early in the harvest season prevented sugar levels from climbing in the already immature stalks; even though rainfall during November and December averaged below normal. Despite the adversity, Louisiana produced a record 893,000 tons, raw value, of sugar, up 2% from the previous record harvest which occurred just one year earlier. Like 1992, the record was not due to the 4990 pounds of sugar per acre yield but to the 360,000 acres harvested; the largest number of acres ever harvested in the state of Louisiana. From these harvested acres, growers reported gross cane per acre yields of 25.7 tons bringing the total amount of cane ground by the 20 raw sugar factories to 9,240,000 tons.

In addition to weather adversities, the industry faced adversity from a host of national and state legislative issues in 1993. These issues ranged in scope from trade issues like NAFTA, GATT and marketing allotments to environmental issues like the Clean Water Act and the development of best management practices, to issues regarding worker protection.

What will 1994 bring? "Five bad years in a row - nah, never" has given away to "five bad years in a row - let's hope not". As of this writing, the crop shows potential, there's a lot of growing season ahead, and that old fashion Louisiana optimism can be summed up in the popular saying of my cajun ancestors "les la bonne temps roule" i.e. "let the good times roll". After four bad years of weather related reductions in per acre cane and sugar yields, the Louisiana Sugarcane Industry is certainly due a roll of good times.

The Mainland U.S. Sugar Industry has probably gotten the best deal it could hope for in the recently completed NAFTA and GATT negotiations. As a result of these trade agreements, we must begin the process of competing in a global economy. To survive in a global economy the cane sugar industry, growers and processors alike, will have to become more efficient. To do this will require research, of which the majority will have to come from the universities and USDA's Agricultural Research Service.

Here in lies a major battle for the Louisiana Sugarcane Industry in 1994. President Clinton's fiscal year 1995 budget does not include funding for the USDA's Houma Station. The significance of this facility's contributions to the Louisiana Sugarcane Industry in the areas of weed control, cultural practices, entomology, pathology, ripening and, oh yes - varietal development, is well documented and recognized throughout the Mainland and World Cane Sugar Industries. Like most states, the sources of revenue for the state of Louisiana are limited, and significant increases in funding to Louisiana State University to fill the potential void in sugarcane research created by a closure of the USDA facility at Houma are not anticipated.

The Louisiana, Florida, and Texas sugarcane industries, LSU and other public research organizations, and John/Jane Q. Public have all voiced their support to the powers to be in Washington to get funding to this facility restored. All of these entities recognize the need for this facility now more than ever as we enter the arena of global competition. The outcry was so great that the Agricultural Subcommittee of the U.S. House of Representative's Appropriations Committee has called for the restoration of funding to this facility; at least in the fiscal year 1995 budget which begins October 1, 1994. This support from the clients, cooperators, and the public is greatly appreciated by the staff of this facility, and I think in the end - if funding is restored -will result in a new era of focused commitment and comradery between all concerned. The fruits of a renewed commitment to cooperative research can not but result in an increase in the quality and quantity of applied research to meet the industry's needs today and basic research to insure the industry's competitiveness for the next 200 years which begins in just a few short months.

One of the things that insured the success of the sugar industry's first 200 years was a willingness by growers and processors to experiment with new ideas. Where would we be today without the efforts of Etienne DeBore' in the 1790's, the management of Southdown Plantation in Terrebonne Parish who addressed the industry-threatening disease problems of the 1920's, and countless others? These individuals weren't trained and paid engineers and researchers; they just saw a problem, had an idea on how to fix it, and compared their way to the old way. What really made their contributions great was that in the end they unselfishly shared what they learned, good and bad, with their counterparts for the betterment of this industry.

In my opinion the remaining portion of the research necessary to become more efficient will have to come from you, the farm shop engineers and nonscientific members of this industry. Be observant, ask what if, experiment, and share your findings with your counterparts, your friends in this industry. In passing on these findings, remember friends are not concerned with experimental errors, analyses of variance, and LSD's; just the bottom line. What better place to share this information than the Division and Joint Meetings of this Society. Which one of you will follow in the footsteps of Etienne DeBore' to insure another 200 years of existence for this industry?

Will 1994 be regarded as a challenging year legislatively speaking? You tell me. On the national level, in addition to blocking the closure of the Houma Station, there's talk about expanding NAFTA beyond the United States, Mexico, and Canada. There's the impending demise of Communism in Cuba and the concerns as to what effect it would have on sugar imports to the United States. There's health care, the Clean Water Act, the wetlands, and issues regarding habitat preservation for the Louisiana Black Bear. Finally, there's the 1995 Farm Bill and the environmentalists just waiting to tack on more restrictions. To obtain a renewal of the farm bill in its present form would be considered a victory, but to whom, and for how long? Within the state of Louisiana there are battles to be fought regarding the freedom to burn the crop and to use our highways to transport the crop to the factories as efficiently as possible. All of these legislative issues threaten to add more non-retrievable costs and further erode profits.

It seems customary for Division Presidents to take out their crystal gavels and make predictions in these welcoming addresses as to where they see the sugarcane industry 10 or 20 years from now. Who knows what the future holds for the Louisiana Sugar Cane Industry in the twenty-first century? I see continued battles with environmentalists/sensationalists. On the other hand, I see a realization by the average man and woman, our consumers and the majority of the population, that these environmentalists/sensationalists are using alarmist tactics to carry out their agendas. Agendas which result in restrictions that are not based on scientific facts and cost/risk assessments and ultimately cost all of us more money. In the future, I see new uses for sugar that will result in expanded markets. Finally, for Louisiana, I see growers combining forces to make new harvesting technology more affordable and factory mergers all in the name of becoming more efficient to insure that this industry remains viable well into the twenty-first century.

Invited guests, ladies, and gentlemen may your stay here be relaxing and enjoyable and may the information you obtain be useful to your continued success in the sugar industry.

PEER REFEREED JOURNAL ARTICLES

SUGARCANE RESPONSE TO SHAVING AND SPRING APPLICATION OF METRIBUZIN AND TRIFLURALIN[1]

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ABSTRACT

Mechanical shaving of the sugarcane row top removes winter weeds, winter-killed crop residues, and stumpage from the previous year's harvest, which facilitates the incorporation of soil-applied herbicides. Results related to the negative effects of shaving on sugarcane growth and yield have been variable. Our objective was to determine response of sugarcane to date of shaving and spring application of herbicides. In field studies conducted 3 yr, sugarcane stalk population of first ratoon CP 70-321 was not reduced by soil incorporation of metribuzin at 2.6 kg/ha or trifluralin at 2.2 kg/ha plus atrazine at 2.1 kg/ha in conjunction with false shaving compared with application of metribuzin plus 2,4-D to undisturbed soil. Delaying application of all herbicides until April 20 or later reduced stalk population an average of 6% compared with application March 1 to March 26. Sugarcane stalk height was reduced regardless of herbicide treatment when application was delayed until March 23 or later. Averaged across application dates, stalk height was greatest when metribuzin was applied to an undisturbed bed, and was reduced 4% when metribuzin followed shaving either with or without incorporation and 6% when trifluralin was used. Sugarcane yield, regardless of herbicide or method of application, was equivalent when treatments were imposed between March 1 and April 10, but was reduced approximately 10% when applied April 20 or later. Results indicate that shaving and incorporation of herbicides can negatively impact sugarcane development. More importantly, herbicide application after April 10 can reduce sugarcane population, height, and yield whether or not shaving is used. **Nomenclature**: atrazine, 6-chloro-*N*-ethyl-*N*'-(1-methylethyl)-1,3,5-triazine-2,4-diamine; metribuzin, 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4*H*)-one; trifluralin, 2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)benzenamine; 2,4-D, (2,4-dichlorophenoxy) acetic acid; sugarcane, trispecific hybrid of *Saccharum*.

INTRODUCTION

The mechanical shaving of the row top is an old practice that replaced hand-hoeing to control weeds on Louisiana sugarcane plantations. Shaving was done in late winter or early spring with a horizontally-mounted revolving disc cutter set to remove 5 to 8 cm of soil from the top of the planted sugarcane row. In addition to removing emerged winter weeds and soil laden with weed seed, the operation removed cover crops, winter-killed sugarcane residues, and stumpage from the previous year's harvest (Arceneaux, 1960; Hebert, 1962; and Hebert and

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[1] Approved for publication by the Director of the Louisiana Agricultural Experiment Station as manuscript number 94-38-8179.

Matherne, 1953).

The necessity of the shaving operation was questioned when herbicides were developed that controlled emerged winter weeds and provided residual control of more competitive summer weeds, such as johnsongrass [*Sorghum halepense* (L.) Pers.]. In the absence of weed pressure, results of shaving studies were somewhat variable and generally indicated that shaved fields yielded less than unshaved fields. The negative effects of shaving were particularly evident when the sugarcane crop was well established following a mild winter and when shaving was delayed until March (Hebert, 1962; and Hebert and Matherne, 1953). It was also observed that sugarcane in shaved fields tended to grow slower and was less competitive with weeds than in unshaved fields (Hebert and Matherne, 1953).

The development of itchgrass [*Rottboellia cochinchinensis* (Lour.) W. Clayton] as a problem weed in Louisiana sugarcane in the early 1950's has been described (Lencse and Griffin, 1991; and Millhollon, 1965). Sequential applications of TCA (trichloroacetic acid) plus 2,4-D followed by TCA plus 2,4-D plus dalapon (2,2-dichloropropanoic acid) were the standard treatment, but control of itchgrass was limited (Millhollon, 1965). Trifluralin soil-incorporated in the spring has been shown to be effective for preemergence itchgrass control (Millhollon, 1972), but removal of plant residue and stumpage from the row top is necessary to facilitate mechanical incorporation with a rolling cultivator. To minimize risk of reduced yield associated with removal of emerged sugarcane shoots during shaving and injury to under-ground stubble buds from mechanical incorporation, only 1 to 3 cm of soil should be removed from the top of the row. This operation is referred to as false-shaving to avoid confusion with the earlier form of shaving where the amount of soil removed was substantially greater.

Once the row top over the line of sugarcane is cleaned by false-shaving, a rolling cultivator containing four 40-cm gangs with five curved tines per gang is used to loosen the soil. Trifluralin is then applied in a 90-cm band to the soil surface over the line of sugarcane and incorporated to a depth of 5 cm with two passes of the rolling cultivator in opposite directions.

Trifluralin is also used in areas where control of seedling johnsongrass (Millhollon, 1972) and browntop panicum (*Panicum fasciculatum* Sw.) are problem weeds in sugarcane (Millhollon, 1977). A significant amount of sugarcane is treated with trifluralin because of its broad spectrum grass control and cost. Alternative surface-applied herbicides that do not require mechanical incorporation have been recently registered for control of itchgrass and seedling johnsongrass in sugarcane (Millhollon, 1993). Since these herbicides are as effective as trifluralin on some weeds, reassessment of potential yield reduction associated with required incorporation of trifluralin is warranted. In previous studies with shaving depths of 5 to 8 cm, date of shaving affected crop response (Hebert, 1962; and Hebert and Matherne, 1953). This study was conducted to determine the effect of date of false-shaving and use of mechanical herbicide incorporation on sugarcane yield.

MATERIALS AND METHODS

Studies were conducted in Louisiana near Raceland in 1988, Lakeland in 1989, and Labadieville in 1990 using first ratoon CP 70-321 growing on medium textured soils. Metribuzin at 2.6 kg/ha, metribuzin plus 2,4-D at 2.6 + 1.3 kg/ha, and trifluralin plus atrazine at 2.2 + 2.1 kg/ha were applied March 1, March 23, and April 20, 1988; March 10, April 6, and April 26, 1989; and March 26, April 10, and April 27, 1990. Attempts were made to apply herbicide treatments in early March, late March - early April, and late April but specific dates varied due to weather conditions. Height of growing cane for the first application each year ranged from

0 to 36 cm, 10 to 46 cm at the second application, and greater than 46 cm at the third application. A hydraulically driven, revolving disk shaver was used to remove approximately 3 cm of soil from the row tops of designated plots. Metribuzin plus 2,4-D was applied to the undisturbed row postemergence to the crop and winter weeds and preemergence to warm-season seedling weeds. Addition of 2,4-D was for control of scattered infestations of emerged cool-season broadleaf weeds. A tractor-mounted sprayer was used to apply herbicide treatments to a 90-cm band using a conventional 3-nozzle per row arrangement of one nozzle in the center of the row and one nozzle on either side of the row on 25 cm drops. Herbicide incorporation of metribuzin or trifluralin plus atrazine was accomplished with two passes of a rolling cultivator in opposite directions.

Sugarcane stalk population was determined in August of each year from the entire experimental plot by counting all stalks with a height of at least 1.8 m. Stalk height was determined in August of 1988 and 1989 on 12 randomly-selected stalks by measuring from the soil surface to the youngest visible dewlap, a structure that is triangular in shape and present where the leaf blade and sheath join. Sugarcane yield was determined in 1988 and 1990 by harvesting plots with a whole stalk mechanical harvester set to top as close to the first hard internode below the apical meristem as possible. Leaf material was removed by burning harvested stalks prior to weighing to determine gross cane yields.

A factorial arrangement of treatments (four herbicides and three application dates) in a randomized complete-block experimental design replicated five times was used each year. Individual plot size was 5.3 m (3 rows) wide and ranged in length from 15.2 to 18.3 m. Data for each variable were analyzed across years and if year interactions were not noted, data were pooled. Means were separated using Fisher's protected Least Significant Difference (LSD) at the 0.05 level of probability.

RESULTS AND DISCUSSION

Averaged across herbicide treatments, stalk population was reduced 6% when treatments were imposed April 20 to April 27 (application 3) compared with March 1 to March 26 (application 1) (Table 1). For the second application March 23 to April 10, stalk population was equivalent to the late application. Sugarcane stalk population response to the herbicide treatments was similar for each application date. When averaged across application dates, sugarcane stalk population was equivalent for the herbicide treatments and averaged 66,280 stalks/ha. Metribuzin is relatively nonphytotoxic to sugarcane (Richard, 1989). Even though not statistically significant ($P = 0.05$), stalk population was greatest numerically when metribuzin was applied with 2,4-D to an undisturbed bed and lowest when trifluralin was applied in conjunction with shaving and incorporation.

As noted for stalk population, stalk height reponse to the herbicide and application times was similar at the locations. Averaged across herbicide treatments, stalk height was reduced 2 and 9% when herbicide treatments were applied March 23 to April 6 and April 20 to April 26, respectively, compared with application March 1 to March 10 (Table 2). Averaged across application dates, stalk height was greatest for metribuzin applied to an undisturbed bed (217 cm) and was reduced 4% when metribuzin was applied in conjuction with shaving or shaving plus incorporation and 6% when trifluralin was applied.

Regardless of herbicide treatment, sugarcane yield was reduced as application date was delayed. Averaged across herbicide treatments, sugarcane yield was equivalent for the first and second application dates (March 1 to April 10) and at least 9% greater than when application was delayed until April 20 to April 27 (Table 3). Sugarcane yield, averaged across application dates was similar for the herbicide treatments and averaged 63.7 mt/ha. There was a trend, even though not significant ($P = 0.05$), toward higher yield when metribuzin was applied without soil disturbance compared with herbicides applied following shaving with or without incorporation. This would be expected since stalk height was greatest when metribuzin was applied to an undisturbed bed (Table 2).

These findings demonstate the importance of early spring application of herbicides for preemergence control of seedling weeds, especially when false shaving and herbicide incorporation is practiced. Early treatment with preemergence herbicides affords the crop a better opportunity to recover from any resulting adverse effects. In these studies stalk height was greatest when metribuzin was applied to an undisturbed bed. Shaving followed by two passes with the rolling cultivator to incorporate trifluralin resulted in shorter stalks than when metribuzin followed shaving with or without incorporation.

Regardless of whether or not false shaving is practiced, delaying herbicide application until April can adversely affect sugarcane stalk population, height, and yield. The negative effect associated with delayed herbicide application should be more pronounced in the southern area of the sugarcane belt due to earlier crop emergence in spring.

ACKNOWLEDGEMENTS

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Table 1. Sugarcane stalk population of first ratoon CP70-321 as influenced by method and date of herbicide application in Louisiana.[a]

Herbicide	Rate	Application Method[c]	Application date[b] 1	2	3	Mean
	kg/ha			no./ha		
Metribuzin	2.6	S	67,290[c]	65,390	66,670	66,450
Metribuzin	2.6	S+I	68,350	66,500	63,780	66,210
Trifluralin + atrazine	2.2 + 2.1	S+I	67,830	65,730	59,660	64,410
Metribuzin + 2,4-D	2.6 + 1.3	None	68,670	68,460	66,940	68,030
Mean			68,040	66,520	64,260	

	LSD (0.05)
Among herbicide treatments	3150[d]
Among application dates	2730
Herbicide x application date interaction	NS

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[a] Values represent an average for the Raceland, Lakeland, and Labadieville, LA locations.

[b] Application 1: March 1 to March 26; Application 2: March 23 to April 10; Application 3: April 20 to April 27.

[c] S = row shaved prior to herbicide application; S+I = row shaved and herbicide incorporated with two passes of rolling cultivator; None = herbicide applied to an unshaved row.

[d] Significant at $P = 0.16$.

Table 2. Sugarcane stalk height of first ratoon CP70-321 as influenced by method and date of herbicide application in Louisiana.[a]

Herbicide	Rate	Application Method[c]	Application date[b] 1	2	3	Mean
	kg/ha			cm		
Metribuzin	2.6	S	213[c]	212	203	209
Metribuzin	2.6	S+I	220	207	198	209
Trifluralin + atrazine	2.2 + 2.1	S+I	213	206	193	204
Metribuzin + 2,4-D	2.6 + 1.3	None	220	221	209	217
Mean			217	212	201	

	LSD (0.05)
Among herbicide treatments	4
Among application dates	4
Herbicide x application date interaction	NS[d]

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[a] Values represent an average for the Raceland and Lakeland, LA locations.

[b] Application 1: March 1 and March 10; Application 2: March 23 and April 6; Application 3: April 20 and April 26.

[c] S = row shaved prior to herbicide application; S+I = row shaved and herbicide incorporated with two passes of rolling cultivator; None = herbicide applied to an unshaved row.

[d] NS = Not significant.

Table 3. Sugarcane yield of first ratoon CP70-321 as influenced by method and date of herbicide application in Louisiana.[a]

			Application date[b]			
Herbicide	Rate	Application Method[c]	1	2	3	Mean
	kg/ha			mt/ha		
Metribuzin	2.6	S	64.3[c]	63.0	57.3	61.5
Metribuzin	2.6	S+I	66.2	62.3	61.1	63.2
Trifluralin + atrazine	2.2 + 2.1	S+I	66.9	66.0	56.8	63.3
Metribuzin + 2,4-D	2.6 + 1.3	None	69.8	68.9	61.7	66.8
Mean			66.8	65.1	59.2	
				LSD (0.05)		
Among herbicide treatments				4.5[d]		
Among application dates				7.8		
Herbicide x application date interaction				NS		

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[a] Values represent an average for the Raceland and Labadieville, LA locations.

[b] Application 1: March 1 and March 26; Application 2: March 23 and April 10; Application 3: April 20 and April 27.

[c] S = row shaved prior to herbicide application; S+I = row shaved and herbicide incorporated with two passes of rolling cultivator; None = herbicide applied to an unshaved row.

[d] Significant at $P = 0.13$.

ASSESSMENT OF SUGARCANE CROP DAMAGE AND YIELD LOSS IN LOUISIANA CAUSED BY HURRICANE ANDREW

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ABSTRACT

Hurricane Andrew struck the Louisiana coastline between Terrebonne and St. Mary parishes (counties) 25-26 August 1992 with sustained winds of 225 km h^{-1} and gusts of 257 km h^{-1}, causing extensive damage to many crops, the vast majority of which was sugarcane (*Saccharum* interspecific hybrids). The `eye' of the storm passed approximately 48 km west of Houma sparing the city and the crop of the most destructive winds. However, it was estimated that winds in excess of 160 km h^{-1} buffeted the area for more than four hours. Its initial northwesterly and later northerly course brought hurricane-force winds across most of the 19 sugarcane-growing parishes of the state.An initial subjective assessment of stalk and leaf damage was made parish-by-parish within two days after Hurricane Andrew. The estimated loss in sugar yields ranged from a low of 10% in the fringe areas of the hurricane's path to more than 50% percent in the area of the eye of the storm. The total loss in sugar yield to Louisiana was estimated at 27% (1.6% reduction in sugar yield per 1% stalk breakage based on 17% average breakage). At harvest (Nov. and Dec.), a second assessment of hurricane damage on sugar yield and its associated components was measured in St. Mary parish, the area hardest hit by the storm. Six cultivars, CP 65-357, CP 70-321, CP 72-370, CP 79-318, LCP 82-89, and LHo 83-153, were evaluated in both the plant-cane and/or ratoon-cane (stubble) fields during the harvest season. From each field, both broken and unbroken stalks were selected at random throughout the field and removed for estimating losses caused by the damage. The estimated percentage of broken stalks in these fields ranged from 20 to 55%. Losses of cane yield (Mg ha^{-1}) per 1% broken stalks averaged 0.19% as an average for all cultivars (range, 0.08% for CP 79-318 to 0.31% for CP 65-357). Estimated losses of theoretical recoverable sugar (TRS) per ton of cane (kg Mg^{-1}) per 1% broken stalks averaged 0.20% across cultivars (range, 0.16% for both LCP 82-89 and LHo 83-153 to 0.25% for CP 79-318). The overall loss in sugar yield following 100% stalk breakage ranged from 30% (LCP 82-89) to 43% (CP 65-357) and averaged 35% (0.35% loss per 1% breakage), indicating that the initial estimate of sugar loss following Hurricane Andrew was over-estimated. The primary effects of hurricane-induced stalk breakage on sugar yield components were on stalk weight and yield of theoretical recoverable sugar per ton and its associated parameters.The tons of cane processed (8.1 million) by the 20 factories during the 1992-93 harvest season amounted to an estimated 14.4% loss assuming that the pre-hurricane estimate of 9.5 million tons was accurate. Further, the estimated loss in total sugar produced amounted to 17.8%, approximately 65% of the pre-harvest assessment of 27% made within two days of the storm. Although it is impossible to calculate the indirect cost of the storm to the industry, it is estimated that Hurricane Andrew caused an estimated $78.8 million in direct monetary losses.

INTRODUCTION

Crop damage from hurricane force winds is one of the hazards of growing sugarcane (*Saccharum* interspecific hybrids) in Louisiana. Breakage of stalks with the resulting loss in cane tonnage is the most common form of damage. However, the actual yield loss depends upon the percentage of broken stalks and the potential reduction in the recoverable sugar per ton of cane. Losses vary greatly depending upon cultivar and the climatic conditions after the storm

(Arceneaux, 1941; Arceneaux *et al.* 1952; Davidson and Irvine, 1966; Hebert and Matherne, 1957; and Legendre, 1987).

Following a tropical storm with winds of 40 to 80 km h^{-1} in Louisiana, Hebert and Arceneaux (1940) noted that there were differences among cultivars in the number and percentage of broken stalks. However, Arceneaux (1941) stated that for accurate appraisals of the economic importance of cultivar susceptibility to wind damage, it is necessary to know how such damage affects maturity or recovery of sugar per ton of cane of the broken stalks. He reported that broken stalks of both plant-cane and first-ratoon crops matured in what appeared to be a near normal manner; however, broken stalks were distinctly inferior to undamaged stalks in recoverable sugar per ton of cane at one to four months following the storm.

In a subsequent study, Arceneaux *et al.* (1952) simulated the effects of hurricane force winds by artificially breaking the tops of millable stalks of three cultivars on 20 August, the approximate date of Hurricane Andrew. Treatments included breaking 0, 20, 40, 60, 80, and 100% of millable stalks. Average reductions in sugar yield ranged from 9.7% when 20% of the stalks were broken to 54.1% when all stalks were broken. They noted that the results reflected a reduction in both cane quality and quantity with differences in responses noted among the three cultivars studied.

Legendre (1987) reported results from field studies made in Louisiana following Hurricane Danny, 14-16 August 1985 with winds of 160 km h^{-1}. He stated that the average percentage of stalks broken in the plant-cane crop was dependent upon cultivar and ranged from less than 1% for NCo 310 to more than 73% in CP 72-356. Average reductions in cane and sugar yield depended on the percentage of broken stalks and, to a lesser extent, on the reduction in recoverable sugar per ton of cane as the cane matured.

Following the hurricane of 25-26 August 1992, field surveys and evaluations were conducted to assess the damage and yield loss. Because sustained, hurricane-force winds are a rare occurrence in Louisiana, little methodology was available for evaluating the extent of the sugarcane crop damage and for estimating sugar loss. This paper reports the results of those surveys and evaluations, and summarizes the effects of Hurricane Andrew on crop damage and yield loss, and documents methodology recommended to estimate sugar loss following future hurricanes.

MATERIALS AND METHODS

After conducting field surveys on 26-28 August 1992 following Hurricane Andrew, personnel of the USDA-ARS (United States Department of Agriculture, Agriculture Research Service) ASCS (Agricultural Stabilization and Conservation Service), LAES and LCES (Louisiana Agricultural Experiment Station and Louisiana Cooperative Extension Service, respectively), PCA (Production Credit Association), and the ASCL (American Sugar Cane League of the U.S.A., Inc.) met in Thibodaux on 28 August to discuss the extent of the damage and to formulate a plan of action for sugarcane growers and processors to follow to minimize the losses incurred because of the storm. Prior to harvest, another meeting was called on 14 September at Baton Rouge by the staff of Sugar Station/Audubon Sugar Institute, LAES, and attended by representatives of most of the State's raw factories and refiners. Topics of discussion included cane delivery, cane quality, milling losses and throughput, clarification and filtration, boiling house operations with emphasis on anticipated lower syrup purities and increased dextran and starch concentrations in factory juice and syrup streams, and boiler operations.

During the harvest (Nov. and Dec.), nine field evaluations were conducted in St. Mary parish, the area hardest hit by the storm. Damage estimates were made in fields of standing cane of six cultivars, CP 70-321, CP 72-370, and LCP 82-89 (plant-cane and ratoon-cane crops), CP 79-318 and LHo 83-153 (plant-cane crop only), and CP 65-357 (ratoon-cane crop only) (Table 1). Attempts were made to estimate the percentage of broken stalks in each field, but because of severe lodging, it was impossible to accurately count stalks to calculate actual percentages of broken stalks. Therefore, to assess the efforts of the storm on sugar yield, it was determined that the best measurement would be to compare the differences in mean stalk weight (kg), and sucrose, purity, and fiber % cane, yield of theoretical recoverable sugar per ton of cane (kg Mg^{-1}), and yield of cane (Mg ha^{-1}) and sugar (kg ha^{-1}) per hectare between 100% unbroken (whole) and broken stalks. From each field, 80 whole and broken stalks (treatments) were selected at random throughout the field, cut at the soil surface, stripped of all senescent leaves, and removed from the field with all growth from axillary buds (lateral shoots) and the green tops of the whole stalks intact. Once outside the field, the tops of the whole stalks were removed at approximately 10 cm below the apical bud. In most cases, lateral buds on broken stalks had begun to germinate and grow; however, no attempt was made to remove this growth. Stalks of each treatment were then divided at random into eight subsamples (replications) containing 10 stalks each. Mean stalk weight was determined for each subsample prior to passing it through a prebreaker to prepare the sample for analysis according to the procedure described by Legendre (1992). A 1,000 g sample of the prepared cane was pressed at 211 kg cm^{-2} pressure for two minutes. The hydraulic press separated the sample into juice (approximately 80% extraction) and residue (bagasse), both of which were analyzed, the former for Brix by refractometer and pol by saccharimeter (Chen, 1985), and the latter only for moisture (by drying) for 24 hours at 60-65° C. Brix, sucrose, purity, and fiber % cane, and yield of theoretical recoverable sugar per ton of cane (kg Mg^{-1}), were calculated from these analyses (Legendre, 1992; and Legendre and Henderson, 1972). Cane tonnage (Mg ha^{-1}) represents the product of mean stalk weight and a constant stalk population of 48,000 and 59,000 stalks ha^{-1}, the approximate average stalk population for the six cultivars in plant and ratoon crops, respectively, from outfield test plots harvested in 1992 (Garrison *et al.* 1994). Sugar yield (kg ha^{-1}) was calculated by multiplying cane tonnage by yield of sugar per ton of cane.

Analysis of variance was conducted for each field evaluation. The F-test (0.05 level of probability) was used to determine whether variations caused by the treatments were significant. Fisher's protected LSD was used for mean separation.

RESULTS AND DISCUSSION

Immediately following Hurricane Andrew on 25-26 August 1992, it was reported that sugarcane had been severely lodged with considerable broken stalks and shredded leaves, especially in Iberia and St. Mary parishes. Initial news reports indicated that the sugarcane crop in Louisiana had been all but destroyed. Within 24 h after the storm, the losses had been downgraded to approximately 50%. Then on 28 August, a subjective assessment was made on a parish-by-parish basis, at which time personnel of the USDA-ARS, ASCS, LAES, LCES, PCA, and ASCL summarized the extent of damage (Table 2). Of the 19 parishes which grow sugarcane in Louisiana, Avoyelles, East Baton Rouge, and Rapides were the least affected by Hurricane Andrew with the greatest damage occurring in St. Mary parish. Post-hurricane assessment estimated that an industry average of 17% of the sugarcane stalks had broken tops and 51% had shredded leaves. Further, it was estimated that the industry would suffer a 27% loss in sugar production as a result of stalk damage from Hurricane Andrew. This figure was comparable to the losses obtained following Hurricane Betsy in 1965, touted as the most destructive storm to strike southeastern Louisiana in the twentieth century (Davidson and Irvine, 1966).

Arceneaux *et al.* (1952) reported that stalk breakage by hurricane-force winds was confined largely to the region of immature joints immediately below the terminal bud. In the present study, it was noted that breakage generally occurred further down the stalk as there was a significant loss in mean stalk weight and cane tonnage in six of the nine evaluations (Tables 3 and 4). Only for the cultivars CP 79-318 (plant-cane crop) and LCP 82-89 (ratoon-cane crop) were the differences in mean stalk weight and cane tonnage between whole and broken stalks not significant although, numerically, there was lower stalk weight and cane tonnage for these two cultivars. However, it was noted that there was considerable development of lateral shoots on broken stalks in some cultivars which may have had a differential effect on the stalk weight. Arceneaux *et al.* (1952) had reported that the development of lateral shoots was cultivar dependent. Legendre (1987) noted that sugar losses increase with time as the weight differences between whole and broken stalks increase. Whole stalks continue to grow while the broken stalk stops growth or diverts growth to non-productive lateral shoots. Undoubtedly, that occurred in the present study as the evaluations were conducted approximately four months after the storm. In an earlier evaluation following Hurricane Danny, stalk weight and cane tonnage of two of three cultivars were not affected until four months after the storm (Legendre, 1987). Besides the loss of cane tonnage due to stalk breakage, Davidson and Irvine (1966) noted that cane left in the field as scrap adds considerably to the overall loss.

Sucrose and purity % cane were significantly less for all evaluations in broken stalks when compared to whole stalks (Tables 5 and 6). Legendre (1987) noted that the difference in sucrose content between whole and broken stalks became more pronounced with time after Hurricane Danny in 1985. Further, the losses in sucrose content were not significant at one month after Hurricane Danny; however, by four months after the storm, the differences were significant. In the present study, the differences in sucrose and purity % cane between whole and broken stalks was exacerbated by the four months between the storm and harvest. Further, both sucrose and purity % cane were, undoubtedly, adversely affected by the growth of the lateral shoots on the broken stalks. No disease or insect infestations were noted in broken stalks. However, in some instances, the internode immediately below the broken top had withered and appeared dried out.

Fiber % cane was significantly lower in broken stalks for CP 70-321 in both the plant-cane and ratoon-cane crops, and numerically, but not significantly lower in four additional evaluations, e.g. CP 65-357 (ratoon-cane crop), CP 72-370 (plant-cane crop), CP 79-318 (plant-cane crop), and LCP 82-89 (ratoon-cane crop); however, fiber % cane was significantly higher in broken stalks for LHo 83-153 in the plant-cane crop and numerically, but not significantly higher in two evaluations, e.g. CP 72-370 (ratoon-cane crop) and LCP 82-89 (plant-cane crop) (Table 7). Undoubtedly, these differences were also due to the number and extent of growth of lateral shoots. Legendre (1987) had previously found that fiber content of broken stalks in one cultivar tended to be higher as the number of lateral shoots on broken stalks increased. Arceneaux *et al.* (1952) had noted that broken stalks were abnormally low in fiber content and yielded juice of relatively low quality. Legendre (1987) also showed that the fiber content of broken stalks was significantly lower for two cultivars taken four months after Hurricane Danny.

Three components, Brix (total soluble solids), sucrose, and fiber % cane, are used to calculate the yield of theoretical recoverable sugar per ton of cane (Legendre, 1992). In the present study, even though fiber % cane was numerically lower in broken stalks in five evaluations (which would tend to increase recoverable sugar), the yield of recoverable sugar per ton of cane was significantly lower for broken stalks when compared to whole stalks in every evaluation, regardless of cultivar, because of the lower sucrose and purity % cane (Table 8). The average difference in the nine evaluations for yield of recoverable sugar per ton of cane between whole and broken stalks was 27.2 kg Mg^{-1} (data not shown). This difference is similar to the results reported by Arceneaux *et al.* (1952) of approximately 25 kg Mg^{-1} for three cultivars between whole and broken stalks. This difference in sugar per ton of cane between whole and broken stalks is likewise increased with time after the storm (Legendre, 1987).

Moore and Osgood (1985) developed a model in Hawaii for estimating sugar losses caused by hurricane-force winds based on the following parameters: 1) stalk growth termination through breakage; 2) metabolic depletion; and 3) reduced assimilation. Although the model was not verified in the present study, there was significant loss of sugar per hectare in every evaluation due to stalk breakage, and presumably metabolic depletion and reduced assimilation (Table 9). The average loss in each evaluation was a function of the loss of cane tonnage and recoverable sugar per ton of cane with each component of yield contributing to the ultimate sugar loss in approximately the same proportions. These results are similar to the findings of Legendre (1987) following Hurricane Danny in 1985.

Using the data obtained from the nine field evaluations, the predicted loss in cane tonnage, yield of recoverable sugar per ton of cane, and yield of recoverable sugar per hectare, regardless of crop age, for each 1% of broken stalks was calculated (Table 10). Losses in cane tonnage per 1% broken stalks averaged 0.19% as an average of all cultivars studied (range, 0.08% for CP 79-318 to 0.31% for CP 65-357). These data indicated that for CP 79-318 the breakage occurred near the bud and for CP 65-357, the breakage occurred further down the stalk. Loss of theoretical recoverable sugar per ton of cane per 1% broken stalks averaged 0.20 % as an average of all cultivars (range, 0.16% for both LCP 82-89 and LHo 83-153 and 0.25% for CP 79-318). These data indicated that broken stalks of both LCP 82-89 and LHo 83-153 apparently continued to mature more so than broken stalks of CP 79-318. Finally, the overall loss in theoretical recoverable sugar per hectare per 1% in broken stalks was 0.35% as an average of all cultivars (range, 0.30% for LCP 82-89 to 0.43% for CP 65-357). These data suggested that the losses in sugar yield for LCP 82-89 following hurricane-force winds would be less than the losses for CP 65-357, relatively speaking. Further, these data disproved the earlier predictions that sugar loss from Hurricane Andrew would exceed 1.6% for each 1% stalk breakage. Also, these data supported the earlier contention that both the loss of cane tonnage and theoretical recoverable sugar per ton of cane contribute equally to the ultimate loss in sugar yield. These data can be used, by cultivar, to predict the loss in sugar yield following hurricane-force winds, provided one knows the actual percentage of broken stalks in the field. Arceneaux (1941) and Arceneaux *et al.* (1952) reported that the loss of sugar resulting from different degrees of injury to cane stalks in August, the month of the present storm, and the accumulation of sugar in storm-damaged stalks might serve as a guide in estimating the loss that can be expected. He stated that, on the average, the percent reduction in yield of sugar per hectare was approximately one-half the percentage of broken stalks, but that the loss was usually less than one-half with a low percentage of breakage, and more than one-half with a high percent of breakage.

Birkett (unpublished data) showed that the lost time % total grinding time for all 20 commercial factories increased in 1992, undoubtedly, as a direct result of the storm and the excessive rainfall (455 mm at Houma) that occurred during the harvest (Sept. through Dec.). Most farmers had to delay harvest initially to plant their next year's crop. When they did commence harvesting, they experienced low load densities of harvested cane due to the crooked stalks, which significantly increased hauling cost. Cane quality, i.e. sucrose and fiber % cane, was surprisingly good considering the harvesting conditions, and the yield of commercially recoverable sugar per ton of cane essentially equalled the previous four-year average. Undoubtedly, the percentage of broken stalks was not as great as originally predicted, resulting in a higher than anticipated recovery of sugar per ton for the industry as a whole. However, filter cake (press mud) increased by 6.4 kg Mg^{-1} cane from a five year average while the pol % filter cake was up only slightly. The cane processed per hour (254 Mg h^{-1}) by the factories actually increased by approximately 13 Mg h^{-1} from a five year average. Pol extraction % cane, pol % bagasse, boiling house efficiency, and molasses purity remained essentially constant from previous years. Production of final molasses per ton of cane (17.81 Mg^{-1}) was a five-year low. Further, there were no reports of excessive dextran or starch linked directly to the hurricane-damaged sugarcane.

In summary, the tons processed (8.1 million) during the 1992-93 harvest amounted to a 14.4% loss assuming that the pre-hurricane estimate of over 9.5 million tons was correct. Further, there was a corresponding loss of total sugar produced of 17.8% (not the 27% as predicted prior to the harvest) due mainly to the lower cane tonnage and to a much lesser extent, lower sugar recovery per ton of cane. Hurricane Andrew caused an estimated $78.8 million in direct monetary losses (assuming a price of sugar at $0.46 kg^{-1}) to the sugarcane growers, processors, and landlords of Louisiana at the first processing level. However, these losses do not take into consideration the increase in field scrap as well as in the cost to plant, harvest, and process the damaged sugarcane or the losses that occurred as a result of the damage to the successive years' crops.

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Table 1. Cultivar, crop age, location, and date of individual evaluations.

Experiment no.	Cultivar	Crop age	Location	Harvest date
1	CP 70-321	Plant-cane	St. Mary parish (county) (Frank Martin Farms)	11-19-92
2	CP 70-321	Ratoon-cane[1/]	St. Mary parish (Frank Martin Farms)	11-19-92
3	CP 72-370	Ratoon-cane	St. Mary parish (Frank Martin Farms)	11-19-92
4	CP 65-357	Ratoon-cane	St. Mary parish (Northside Planting Co.)	12-02-92
5	CP 72-370	Plant-cane	St. Mary parish (Northside Planting Co.)	12-02-92
6	CP 79-318	Plant-cane	St. Mary parish (Northside Planting Co.)	12-02-92
7	LCP 82-89	Plant-cane	St. Mary parish (Northside Planting Co.)	12-02-92
8	LCP 82-89	Ratoon-cane	St. Mary parish (Northside Planting Co.)	12-02-92
9	LHo 83-153	Plant-cane	St. Mary parish (Northside Planting Co.)	12-02-92

[1/] First- or second-ratoon crop.

Table 2. Parish-by-parish assessment of damage to sugarcane in Louisiana resulting from Hurricane Andrew, 25-26 August 1992.[1]

Parish (county)	Sugarcane area	Broken tops	Shredded leaves	Sugar loss
	(ha)	%		
Ascension	6,723	5	100	20
Assumption	14,985	5	50	20
Avoyelles	4,455	0	0	10
E. Baton Rouge	45	0	0	0
Iberia	23,085	20	75	35
Iberville	14,013	30	50	30
Lafayette	4,050	5	10	15
Lafourche	13,440	10	10	20
Pointe Coupee	6,480	10	70	30
Rapides	1,417	0	0	10
St. Charles	850	<5	15	10
St. James	10,125	5	5	20
St. John	3,240	2	20	10
St. Landry	1,417	10	50	20
St. Martin	13,770	10	75	25
St. Mary	18,630	60	90	50
Terrebonne	4,495	1	30	25
Vermillion	7,290	5	10	15
W. Baton Rouge	4,617	10	65	30
Totals/Averages	153,128	17	51	27

[1] Prepared by the American Sugar Cane League of the U.S.A., Inc. from data supplied by personnel of the United States Department of Agriculture (Agriculture Research Service and Agricultural Stabilization and Conservation Service), Louisiana Agricultural Experiment Station and Louisiana Cooperative Extension Service), Production Credit Association and American Sugar Cane League.

Table 3. Effect of stalk breakage on mean stalk weight following hurricane-force winds assuming fields of 100% whole and broken stalks.

Cultivar	Crop age	Mean stalk weight		Percent	
		Whole	Broken	difference	CV
		------------ kg ------------		---------- % -----------	
CP 65-357	Ratoon-cane[1/]	0.66	0.46*	30.3	8.1
CP 70-321	Plant-cane	0.86	0.69*	19.8	8.9
	Ratoon-cane	0.95	0.69*	27.4	6.1
CP 72-370	Plant-cane	0.87	0.73*	16.1	8.9
	Ratoon-cane	0.95	0.78*	17.9	6.9
CP 79-318	Plant-cane	0.90	0.83NS	7.8	11.1
LCP 82-89	Plant-cane	1.01	0.79*	21.8	7.0
	Ratoon-cane	0.67	0.60NS	10.4	14.9
LHo 83-153	Plant-cane	0.77	0.63*	18.2	5.9
Mean	Plant-cane	0.88	0.73*	17.0	
	Ratoon-cane	0.81	0.63*	22.2	

[1/] First- or second-ratoon crop.

* Significantly different at *P* = 0.05; NS = Not significantly different.

Table 4. Effects of stalk breakage on estimated cane tonnage following hurricane-force winds assuming fields of 100% whole and broken stalks.[1]

Cultivar	Crop age	Cane tonnage Whole	Cane tonnage Broken	Percent difference	CV
		-------- Mg ha^{-1} --------		--------- % ---------	
CP 65-357	Ratoon-cane[2]	39.0	27.0*	30.7	8.1
CP 70-321	Plant-cane	41.1	33.3*	19.1	8.8
	Ratoon-cane	56.3	40.4*	28.2	6.1
CP 72-370	Plant-cane	41.7	35.2*	15.6	8.8
	Ratoon-cane	56.0	46.3*	17.2	6.8
CP 79-318	Plant-cane	43.2	39.8NS	7.8	11.0
LCP 82-89	Plant-cane	48.6	37.7*	22.4	7.0
	Ratoon-cane	39.5	35.7*	9.5	14.9
LHo 83-153	Plant-cane	36.9	30.2*	18.1	6.0
Mean	Plant-cane	42.3	35.2*	16.7	
	Ratoon-cane	47.7	37.4*	21.6	

[1] Estimates of cane tonnage represent the product of mean stalk weight (Table 3) and an assumed constant stalk population of 48,000 and 59,000 stalks ha^{-1} in plant and ratoon crops, respectively, for the six cultivars included in the study.

[2] First- or second-ratoon crop.

* Significantly different at $P = 0.05$; NS = Not significantly different.

Table 5. Effects of stalk breakage on sucrose percent cane following hurricane-force winds assuming fields of 100% whole or broken stalks.

Cultivar	Crop age	Sucrose % cane Whole	 Broken	Percent difference	CV
		----------- %	------------	---------- %	---------
CP 65-357	Ratoon-cane[1/]	16.52	13.79*	16.5	7.1
CP 70-321	Plant-cane	14.40	11.58*	19.6	4.8
	Ratoon-cane	14.29	11.07*	22.5	5.9
CP 72-370	Plant-cane	15.48	13.70*	11.5	4.9
	Ratoon-cane	15.13	11.86*	21.6	4.2
CP 79-318	Plant-cane	15.48	12.08*	22.0	6.1
LCP 82-89	Plant-cane	15.72	13.72*	12.7	7.4
	Ratoon-cane	16.44	13.94*	15.2	7.5
LHo 83-153	Plant-cane	17.42	14.93*	14.3	3.9
Mean	Plant-cane	15.70	13.20*	15.9	
	Ratoon-cane	15.59	12.66*	18.8	

[1/] First- or second-ratoon crop.

* Significantly different at *P* = 0.05.

Table 6. Effects of stalk breakage on purity percent cane following hurricane-force winds assuming fields of 100% whole and broken stalks.

Cultivar	Crop age	Purity % cane Whole	Purity % cane Broken	Percent difference	CV
		----------- %	------------	--------- %	-----------
CP 65-357	Ratoon-cane[1/]	91.43	86.88*	5.0	1.6
CP 70-321	Plant-cane	90.33	83.73*	7.3	1.9
	Ratoon-cane	88.55	81.54*	7.9	2.4
CP 72-370	Plant-cane	91.05	86.80*	4.7	1.6
	Ratoon-cane	89.48	83.26*	7.0	1.1
CP 79-318	Plant-cane	91.27	82.83*	9.2	2.4
LCP 82-89	Plant-cane	89.82	85.21*	5.1	2.8
	Ratoon-cane	92.16	87.00*	5.6	2.7
LHo 83-153	Plant-cane	92.51	88.45*	4.4	1.2
Mean	Plant-cane	91.00	85.40*	6.2	
	Ratoon-cane	90.40	84.67*	6.3	

[1/] First- or second-ratoon crop.

* Significantly different at *P* = 0.05.

Table 7. Effects of stalk breakage on fiber percent cane following hurricane-force winds assuming fields of 100% whole or broken stalks.

Cultivar	Crop age	Fiber % cane Whole	Fiber % cane Broken	Percent difference	CV
		%	%	%	%
CP 65-357	Ratoon-cane[1/]	12.67	12.42NS	-2.0	6.2
CP 70-321	Plant-cane	13.34	12.74*	-4.5	2.9
	Ratoon-cane	12.24	11.82*	-3.4	2.6
CP 72-370	Plant-cane	12.59	12.40NS	-1.5	4.3
	Ratoon-cane	12.46	13.01NS	4.4	4.2
CP 79-318	Plant-cane	10.98	10.68NS	-2.7	5.2
LCP 82-89	Plant-cane	10.89	11.03NS	1.3	9.2
	Ratoon-cane	12.39	12.22NS	-1.4	4.7
LHo 83-153	Plant-cane	10.61	11.35*	7.0	4.9
Mean	Plant-cane	11.68	11.64NS	-0.3	
	Ratoon-cane	12.44	12.37NS	-0.6	

[1/] First- or second-ratoon crop.

* Significantly different at $P = 0.05$; NS = Not significantly different.

Table 8. Effects of stalk breakage on yield of theoretical recoverable sugar per ton of cane following hurricane-force winds assuming fields of 100% whole or broken stalks.

Cultivar	Crop age	Sugar/ton Whole	 Broken	Percent difference	 CV
		--------- kg Mg^{-1} --------		--------- % ----------	
CP 65-357	Ratoon-cane[1/]	146.0	119.4*	18.2	8.1
CP 70-321	Plant-cane	126.0	98.1*	22.1	5.9
	Ratoon-cane	124.9	93.1*	25.5	7.0
CP 72-370	Plant-cane	136.7	118.5*	13.3	5.6
	Ratoon-cane	132.7	100.0*	24.6	4.9
CP 79-318	Plant-cane	138.6	103.4*	25.4	7.3
LCP 82-89	Plant-cane	140.0	118.9*	15.1	8.6
	Ratoon-cane	146.2	121.0*	17.2	8.7
LHo 83-153	Plant-cane	157.3	131.3*	16.5	4.4
Mean	Plant-cane	139.7	114.0*	18.4	
	Ratoon-cane	137.4	108.4*	21.1	

[1/] First- or second-ratoon crop.
* Significantly different at *P* = 0.05.

Table 9. Effects of stalk breakage on estimated sugar yield following hurricane-force winds assuming fields of 100% whole or broken stalks.[1/]

Cultivar	Crop age	Sugar yield Whole	Sugar yield Broken	Percent difference	CV
		---------- kg ha^{-1}	---------	---------- %	--------
CP 65-357	Ratoon-cane[2/]	5,672	3,243*	42.8	12.6
CP 70-321	Plant-cane	5,190	3,265*	37.1	13.2
	Ratoon-cane	7,043	3,753*	46.7	9.6
CP 72-370	Plant-cane	5,693	4,158*	27.0	8.4
	Ratoon-cane	7,419	4,614*	37.8	10.4
CP 79-318	Plant-cane	5,962	4,136*	30.6	15.9
LCP 82-89	Plant-cane	6,813	4,475*	34.3	12.0
	Ratoon-cane	5,771	4,329*	25.0	20.7
LHo 83-153	Plant-cane	5,811	3,966*	31.7	7.9
Mean	Plant-cane	5,894	4,000*	32.1	
	Ratoon-cane	6,476	3,984*	38.5	

[1/] Sugar yield estimates are based on mean stalk weight (Table 3) and yield of theoretical recoverable sugar per ton of cane (Table 8) and an assumed constant stalk population of 48,000 and 59,000 stalks ha^{-1} in plant and ratoon crops, respectively, for the six cultivars included in the study.

[2/] First- or second-ratoon crop.

* Significantly different at $P = 0.05$.

Table 10. Estimated losses in cane tonnage, theoretical recoverable sugar per ton of cane, and yield of sugar per hectare, regardless of crop age, for each 1% in broken stalks as a result of Hurricane Andrew, 25-26 August 1992.

	Losses for each 1% in broken stalks					
Cultivar	Cane tonnage		Sugar/ton		Sugar yield	
	Mg ha^{-1}	(%)	kg Mg^{-1}	(%)	kg ha^{-1}	(%)
CP 65-357	0.120	0.31	0.266	0.18	24.29	0.43
CP 70-321	0.119	0.24	0.299	0.24	26.07	0.42
CP 72-370	0.081	0.17	0.254	0.19	21.70	0.32
CP 79-318	0.034	0.08	0.352	0.25	18.26	0.31
LCP 82-89	0.073	0.17	0.231	0.16	18.90	0.30
LHo 83-153	0.067	0.18	0.260	0.16	18.45	0.32
Averages	0.082	0.19	0.272	0.20	21.27	0.35

GROWTH AND YIELD OF SUGARCANE AS AFFECTED BY JOHNSONGRASS (*SORGHUM HALEPENSE*) INTERFERENCE

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ABSTRACT

Johnsongrass is a severe weed pest of sugarcane (*Saccharum* interspecific hybrids) in Louisiana. The objective of this study was to characterize growth and yield of sugarcane as affected by johnsongrass interference which began as seedlings in newly planted sugarcane and continued as rhizomes in the ratoon crop. A first-yr crop of sugarcane (cultivar CP 65-357) was seeded with johnsongrass in early March to give 1 plant per 30.5 cm of row length (1.8 plants/m^2). The rhizomatous infestations that developed were either removed at intervals in the first-yr crop or were allowed to overwinter and continue into the ratoon (second-yr) crop before removal treatments were initiated (seedling infestations were controlled with herbicides). Johnsongrass biomass in the first-yr crop increased 35 fold from May to July, and biomass from overwintering johnsongrass in the second-yr crop increased over 10 fold during this period. As the duration of johnsongrass interference increased in each crop, sugarcane stalk population decreased and in turn caused a proportional decrease in cane and sugar yield. Johnsongrass removed in May, June, July, and at the November harvest in each crop (two experiments) reduced cane yield an average of 3, 10, 19, and 23%, respectively, in the first-yr crop and 7, 15, 25, and 42%, respectively, in the second-yr crop, as compared to weed-free controls. In a third experiment with a higher infestation of johnsongrass and a lower population of sugarcane, yield reduction in the second-yr crop was 8, 27, 63, and 86%, respectively. Stalk wt was not adversely affected by johnsongrass removal treatments in the first two experiments, but in the third experiment stalk wt was reduced by 13, 34, and 15% at the June, July, and November removal dates, respectively. Full-season johnsongrass interference usually increased theoretical recoverable sugar (TRS) in sugarcane juice as compared to the weed-free control, but johnsongrass removed in June or July either had no negative effect on TRS (first-yr crop) or decreased TRS (second-yr crop). Sugarcane recovered substantially from johnsongrass competition when grown under weed-free conditions during the year following johnsongrass removal, yielding 95% of control when johnsongrass interference lasted one year and 89% when it lasted two years. Because of greater competition from sugarcane, May-germinating johnsongrass had a lower survival rate and accumulated less biomass than March-germinating johnsongrass.

INTRODUCTION

Johnsongrass is a tall, heavy tillering perennial grass that propagates from seed and rhizomes. It is considered one of the world's most noxious weeds and is a problem in a wide range of warm-season crops in many tropical and subtropical regions of the world (Holm et al.,1986 and McWhorter, 1973). In the United States johnsongrass is a severe weed pest of sugarcane in Louisiana and Texas, but it is not yet a weed of great economic importance in Florida and Hawaii. Studies with natural infestations of johnsongrass in Louisiana have shown that full-season johnsongrass interference can reduce cane and sugar yield from 36 to 84%, depending on such factors as density of the infestation, crop year, and sugarcane cultivar being grown (Ali et al., 1986; Millhollon, 1976; Millhollon, 1980; and Richard, 1990). Johnsongrass interference with sugarcane growth appears to be caused by competition for light, nutrients, and moisture, but allelopathy could also be involved (Mikylas, 1984).

Johnsongrass follows a predictable pattern of development in Louisiana sugarcane because of the climate and cultural practices. The region has an 8-month growing season that extends from March to November with relatively mild winters. The crop cycle usually consists of a newly-planted (first-yr) crop and two ratoon (second- and third-yr) crops with annual harvests in fall. The third-yr crop is destroyed after harvest in October, and the land is fallowed until August when it is again available for planting. The fallow period serves to kill johnsongrass rhizomes and to reduce the soil bank of seed. Johnsongrass infestations in the first-yr crop, following the fallow and winter period, primarily originate from seed whereas subsequent infestations in the ratoon crops originate from both seed and rhizomes. Rhizomatous johnsongrass is the primary problem in ratoon crops since preemergence herbicides are available for control of seedlings. Johnsongrass seedlings usually begin to develop rhizomes within 3 to 4 weeks after emergence (McWhorter, 1973). The crown or ratoon buds of sugarcane and the rhizome buds of johnsongrass survive winter in a semi-dormant state and initiate growth in ratoon crops of sugarcane when temperatures warm in early spring. Rhizomatous johnsongrass infestations increase rapidly in the ratoon crops (Millhollon, 1990).

This series of experiments was conducted to characterize growth and yield of sugarcane as affected by johnsongrass interference which began as seedlings in newly planted sugarcane and continued as rhizomes in the ratoon crop.

MATERIALS AND METHODS

Three field experiments were conducted on Mhoon silt loam soil (fine-silty, mixed, nonacid, thermic, Typic Fluvaquent, 1.6% organic matter) at the USDA, ARS Sugarcane farm near Houma, LA. during 1977 to 1979 (experiment 1), 1978 to 1981 (experiment 2), and 1982 to 1984 (experiment 3). Treatments were dates of johnsongrass removal arranged in randomized complete blocks and replicated six or seven times. Plots, three rows (1.8-m spacing) by either 12.2 m (experiments 1 and 2) or 6.1 m (experiment 3), were separated by a 61-cm alley and adjacent three-row plots were separated by a buffer row of sugarcane.

Whole stalks of cultivar CP 65-357 sugarcane, approximately 1.8 m in length with leafy tops removed above the apical meristem, were planted in October in a furrow on top of raised beds. Stalks were planted in pairs with the bottom ends of successive stalk pairs overlapping the top ends by about 10%. In spring, johnsongrass seed, scarified with sandpaper in a commercial seed scarifier, were sown in hills spaced 30.5 cm apart along a line parallel to and 15 cm from the center of the line of sugarcane and, following germination, were thinned to initially give 1 plant/hill (1.8 plants/m^2). Seed were planted either in early March for plots that were to be removed at intervals during the year, or on May 10 for a late-planting treatment that was to continue until sugarcane harvest.

For general weed control, plots were treated preemergence with atrazine (6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine) at 2.2 kg ai/ha as a band treatment, 91-cm wide, in October after planting sugarcane and as a directed treatment during the following April in the first-yr crop. Metribuzin (4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one) at 1.6 kg ai/ha was applied preemergence as a band treatment in March in the second-yr crop and as a broadcast treatment in June in the first- and second-yr crops to control johnsongrass seedlings produced by johnsongrass plants. Metribuzin controls johnsongrass seedlings preemergence without causing injury to sugarcane (Millhollon, 1977), and no injury to rhizomatous johnsongrass has been observed at the rate used. The water furrows and sides of beds were tilled periodically with a disk cultivator. and supplementary handweeding was performed at intervals as required. Plots were fertilized in May each yr with 112 kg/ha N. Soil test had shown that P and K were adequate for good growth of sugarcane.

In experiments 1 and 2, johnsongrass infestations were either removed in the first-yr crop or were allowed to continue into the second-yr crop before removal treatments were initiated. In experiment 3, johnsongrass was only removed in the second-yr crop. Johnsongrass was removed initially after good stands of johnsongrass developed in spring, May 15 and May 1 in the first- and second-yr crops, respectively, and then at 30-day intervals through July and at harvest in November. Initial johnsongrass infestations in the second-yr crop approached 100% on top of beds around sugarcane plants. Johnsongrass was removed by first clipping plants at ground level and then spraying the regrowth with MSMA (monosodium salt of methylarsonic acid) at 4.4 kg/ha using a shield to prevent spray from contacting the sugarcane. Johnsongrass removed at harvest in November was not treated with MSMA unless plots were to continue weed free, in which case MSMA was applied on April 15 of the following year. Two applications of MSMA at 4-wk intervals were usually required to kill plants. After johnsongrass was removed in the first- or second-yr crops of experiments 1 and 2, plots were maintained weed free during the remainder of the growing season and during the following year (second- or third-yr crop) by the herbicide treatments described and supplementary hoeing. Yield from weed-free plots in the year following johnsongrass removal was used as a measure of the residual effect of johnsongrass interference that occurred during the previous year or previous two years, depending on whether johnsongrass was removed in the first- or second-yr crops, respectively.

Total johnsongrass biomass per plot was obtained at the time of removal by drying the clipped vegetation in an oven for 48 h at 70 C. Johnsongrass biomass was not obtained in November for the second-yr crops because of lodging of sugarcane and deterioration of johnsongrass aerial growth. Stalks of sugarcane in each plot were mechanically harvested in November, burned to remove the remaining leaf trash, and weighed. Fifteen stalks were randomly selected from each plot and crushed once in a three-roller sample mill. The juice was analyzed for Brix by hydrometer and for sucrose by polarimetry using standard methods (Meade and Chen, 1977). Theoretical recoverable sugar (TRS) was calculated by methods previously described (Legendre and Henderson, 1973). Other data included the number of harvestable stalks (stalks of at least 1.2 m in height), height of stalks at harvest in some crops as measured from ground to the youngest visible dewlap (a triangular area just above the ligule that forms the hinge of the blade joint in the sugarcane leaf), and average stalk wt as determined from plot wt and stalk number.

The primary quantitative measures of the effect of johnsongrass interference on growth of sugarcane were cane yield, which is the product of stalk population per unit area and stalk wt, and sugar yield, which is the product of cane yield and TRS. Data from individual and combined experiments were analyzed statistically by analysis of variance and means were separated using an LSD test at the 0.05 level of probability.

RESULTS AND DISCUSSION

In the first-yr crop of sugarcane (experiments 1 and 2), johnsongrass biomass increased over 35 fold from May 15 to July 15 as temperatures increased and plant growth accelerated (Table 1). During this period, johnsongrass germinating in March increased from 41 to 200 cm in height, and the number of tillers/plant increased from 2 to 10 (data not presented). Sugarcane tillered profusely from May 15 to June 15 as shown by the shoot population data and, as is typical, produced many more shoots than could be matured into stalks. Initial johnsongrass biomass accumulation between the March planting date and May 15 did not affect sugarcane shoot population in May or June, or stalk population, stalk height, or yield of cane and sugar at the November harvest. However, johnsongrass allowed to develop until June 15, July 15, or November 1 caused a decrease in stalk population at harvest (12 to 23%), stalk height (6 to 11%), cane yield (10 to 23%), and sugar yield (7 to 17%), as compared with the weed-free control. Stalk weight, a component of cane yield, was not negatively affected by johnsongrass interference compared to the weed-free control. Johnsongrass competition that persisted until June 15 had no effect on TRS of stalks, but competition that persisted until July 15 or November 1 increased TRS by 6%.

Table 1. Sugarcane growth and yield in the first-yr crop as affected by date of johnsongrass germination and removal (experiments 1 and 2 combined).

Johnsongrass				Sugarcane							
						Stalk development at harvest				Yield	
Approx. germination date	Plant surv.[a]	Removal date	Dry wt	Shoot pop. 5/15	Shoot pop. 6/15	No.	Ht	Wt	TRS[b]	Cane	Sugar
	%		kg/ha	-- no./ha x 10^3 --			cm	(g x 10)	g/kg	kg/ha x 10^3	
March 15	99	May 15	68	103	141	76	320	112	124	77	9.6
March 15	99	June 15	994	103	123	66	312	119	129	71	9.2
March 15	99	July 15	2416	103	123	59	304	118	134	64	8.5
March 15	99	Nov. 1	2430	103	123	58	305	116	133	61	8.2
May 15	55	Nov. 1	45	107	143	77	322	112	124	79	9.9
Weed free	---	---	---	107	142	75	323	115	126	79	9.9
LSD (0.05)	8		650	NS	8	2	10	5	6	2	0.6

[a] Survival of johnsongrass seedlings during the growing season after being thinned to one plant/30.5 cm of row length.

[b] Theoretical recoverable sugar from stalks.

Johnsongrass that germinated on May 15 had a survival rate of only 55% in the first-yr crop, as compared to 99% when germination was on March 15 (Table 1.) The plants accumulated very little biomass during the growing season and did not affect sugarcane development and yield. After overwintering, the survival rate of the original plants was only 18%, but these rhizomatous plants reduced cane yield in the second-yr crop by 5% (data not presented). These data show that sugarcane can compete effectively with seedling johnsongrass that germinates during the period when sugarcane is actively tillering. Other studies have shown that sugarcane cultivars vary in their effectiveness to compete with seedling johnsongrass and itchgrass [*Rottboellia cochinchinensis* (Lour.) Clayton] (Millhollon, 1990 and Millhollon, 1992). Cultivars that germinate rapidly and that produce abundant tillers in early spring, such as CP 65-357 in this study, were best suited for culture in competition with johnsongrass and itchgrass.

In the second-yr crop, sugarcane and rhizomatous johnsongrass began to emerge from soil after winter and grew slowly under cool spring temperatures. Because of the slow growth, johnsongrass biomass accumulation was much lower at the May 1 removal date than at later removal dates (Table 2). Growth accelerated as temperatures warmed, and biomass increased 10 to 12 fold, depending on experiment, from May to July. The johnsongrass biomass at each removal date was more than twice as much in experiment 3 as in experiments 1 and 2, probably as a result of differences in cane stands (stalk population) which was higher in the weed-free control for experiment 1 and 2 than for experiment 3 (Table 2). This greater sugarcane population probably provided greater competition with johnsongrass. As observed in the first-yr crop (Table 1), sugarcane stalk population decreased as the duration of johnsongrass interference increased, and this reduction in stalk population caused a comparable decrease in cane and sugar yield. Johnsongrass infestations that persisted until the May, June, July, and November removal dates reduced cane yield 7, 15, 25, and 42%, respectively, as an average of experiments 1 and 2, and 8, 27, 63, and 86%, respectively, in experiment 3, as compared to the weed-free controls. Reductions in sugar yield was of a similar magnitude. As expected, yield reduction from full-season johnsongrass interference (November removal date) was greater in the second-yr crop than in the first-yr crop because of the effect of two years of johnsongrass competition rather than a single year (Table 2).

The effects of johnsongrass-removal treatments on stalk wt in the second-yr crop varied among experiments (Table 2). In experiments 1 and 2, stalks weighed more at the July and November removal dates than at earlier removal dates or in the weed-free control whereas in experiment 3 stalks weighed less than the control at the June to November removal dates. Since sugarcane responds to johnsongrass competition by producing fewer tillers and harvestable stalks, stalk wt would be expected to remain relatively uniform under such competition. Such was the case at the different durations of johnsongrass interference in the first-yr crop of experiments 1, 2, and 3 (Tables 1 and 2), and in studies conduced by Ali et al. (1986). However, the very heavy infestation of johnsongrass in the second-yr crop of experiment 3 reduced stalk wt by 13, 34, and 15% at the June, July, and November removal dates, respectively, as compared to the weed-free control. The large reduction in stalk wt at the July removal date probably occurred because stalks that developed after johnsongrass removal had less height and were relatively immature at harvest, as shown by the low TRS (Table 2).

TRS in the second-yr crop of all three experiments varied with date of johnsongrass removal, being lower than the weed-free control when johnsongrass was removed in June and July and equal to or higher than the control when johnsongrass remained throughout the growing season (November removal date) (Table 2). The consistently higher TRS for treatments in experiment 3, as compared to experiments 1 and 2, probably was the result of the later harvest date in experiment 3 and consequently more mature cane. Removing johnsongrass during June and July had the effect of reducing the average age of stalks at harvest because new shoots were observed after johnsongrass removal, and many of these shoots undoubtedly produced stalks. These late-forming stalks, having a low TRS at harvest because of immaturity, probably were responsible for the generally lower TRS in the June- and July-removal treatments as compared to the weed-free control (Table 2). In contrast, full-season johnsongrass interference prevented new sugarcane growth; therefore, the stalks in this treatment were older, more mature at harvest, and consequently had a TRS that was either higher than the weed-free control (experiments 1 and 2) or equal to the control (experiment 3). The higher TRS associated with sugarcane under full-season johnsongrass interference was observed in the first-yr crop of this study (Table 1) and has been observed in other weed-interference studies (Ali et al., 1986; Millhollon, 1976; Millhollon, 1990; and Millhollon, 1992). However, sugar yield is the product of cane yield and TRS, and full-season johnsongrass interference consistently reduced sugar yield because of the large reduction in cane yield in both crops (Tables 1 and 2).

Table 2. Sugarcane growth and yield as affected by full-season johnsongrass interference in the first-yr crop and date of johnsongrass removal in the second-yr crop (experiments 1 and 2 combined and experiment 3).[a]

Johnsongrass			Sugarcane											
Removal			Stalk development at harvest								Yield			
date	Dry wt		Pop.		Ht		Wt		TRS[c]		Cane		Sugar	
by crop	C[b]	3	C	3	C	3	C	3	C	3	C	3	C	3
	-(kg/ha x 10^3)-		-(no./ha x 10^3)-		-- cm --		(g x 10)		-- g/kg --		-- kg/ha x 10^3 --			
First-yr:														
Nov. 1, 30[d]	2.4	---	58	45	305	---	116	110	133	145	61	50	8.2	7.2
Weed free	---	---	75	69	323	---	115	101	126	143	79	69	9.9	9.9
LSD (0.05)			2	9	10		NS	NS	5	NS	2	10	0.6	1.5
Second-yr:														
May 1	0.3	0.5	79	55	---	233	89	81	105	145	64	45	6.8	6.4
June 1	1.3	2.2	75	47	---	210	86	77	98	136	59	36	5.7	4.9
July 1	3.0	6.0	60	31	---	187	96	58	105	124	52	18	5.5	2.3
Nov. 1, 30[d]	---	---	43	10	---	204	101	75	126	148	40	7	5.0	1.1
Weed free	---	---	86	55	---	245	89	88	112	147	69	49	7.7	7.1
LSD (0.05)	0.3	0.4	4	7		10	3	8	7	4	3	7	0.6	1.0

[a] Dashes indicate no data were obtained.
[b] C = experiments 1 and 2 combined.
[c] Theoretical recoverable sugar from stalks.
[d] Removed at harvest: November 1 for experiments 1 and 2 (C) and November 30 for experiment 3.

Sugarcane recovered significantly from johnsongrass interference in experiments 1 and 2 as shown by the improvement in cane yield when plots were maintained weed-free during the year following johnsongrass removal in the first- or second-yr crops (Figures 1 and 2). The recovery in cane yield was possible only because of a similar recovery in stalk population (data not presented). Johnsongrass removed during June and July in the first-yr crop, which reduced yield by 9 and 19%, respectively, caused no significant yield reduction in the weed-free second-yr crop; and full-season johnsongrass interference (November removal date), which reduced yield by 22% in the first year, caused only a 5% yield reduction in the second year (Figure 1). Johnsongrass removed in June, July, and November in the second-yr crop, which reduced yield 15, 25, and 43%, respectively, also reduced yield during the following weed-free third-yr crop by 7, 7, and 11%, respectively, indicating that significant but only partial recovery was obtained (Figure 2). The extent to which sugarcane can recover from johnsongrass interference depends on how rapidly sugarcane stands can be regenerated. Also, if johnsongrass competition has caused the death of stools of sugarcane, either directly or in combination with low winter temperatures or other factors, yield recovery will be limited by the extent of the stool mortality. No data was obtained on yield recovery in experiment 3, but the recovery from two years of full-season johnsongrass interference in that experiment, which caused an 86% reduction in cane yield, would probably be less than the recovery found for that treatment in experiments 1 and 2, which caused a 43% reduction.

In a study similar to this one (Millhollon, 1992), itchgrass, which is a tall, heavy-tillering, annual, grass weed, affected sugarcane growth and yield in an almost identical manner to that found for johnsongrass. The recovery of sugarcane from itchgrass competition was also very similar to that found for johnsongrass. Itchgrass reproduces only by seed, but yield reductions in the first- and second-yr crops were similar to those caused by johnsongrass rhizomes. Thus, the effects of johnsongrass interference on growth and yield of sugarcane probably would have been even greater than that shown in this study if seedlings had not been controlled with herbicides.

These experiments documented several important relationships between johnsongrass interference and sugarcane growth and yield under Louisiana growing conditions: (1) rhizomatous johnsongrass infestations developed rapidly from relatively moderate initial seedling infestations in the sugarcane first-yr crop, showing the importance of maintaining very high levels of seedling johnsongrass control; (2) sugarcane was much more competitive when johnsongrass germinated in May rather than March since sugarcane growth and stand development was very slow under the cool temperatures of early spring; (3) rhizomatous johnsongrass infestations that developed in the first-yr crop, overwintered and began to compete with the sugarcane second-yr crop early in the growing season, causing greater yield loss in the second year than the first year; (4) sugarcane population and cane yield decreased as the period of johnsongrass interference increased each year, but major yield loss was prevented by removing johnsongrass in early May before johnsongrass growth accelerated; and (5) sugarcane recovered substantially from two years of johnsongrass interference, indicating that the effects of johnsongrass interference are reversible as long as the surviving sugarcane stools have the capacity to regenerate stands.

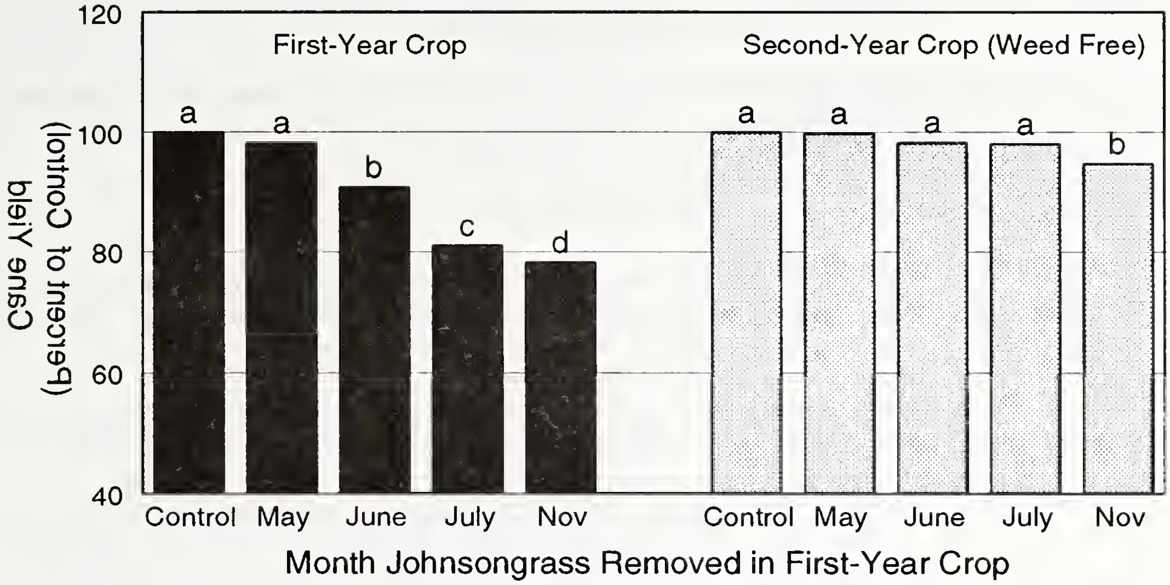

Figure 1. Effect of johnsongrass removal dates in the first-year crop on subsequent cane yield in the first year and the following weed-free second year. Bars within a crop year with the same letter are not significantly different (LSD, $P=0.05$).

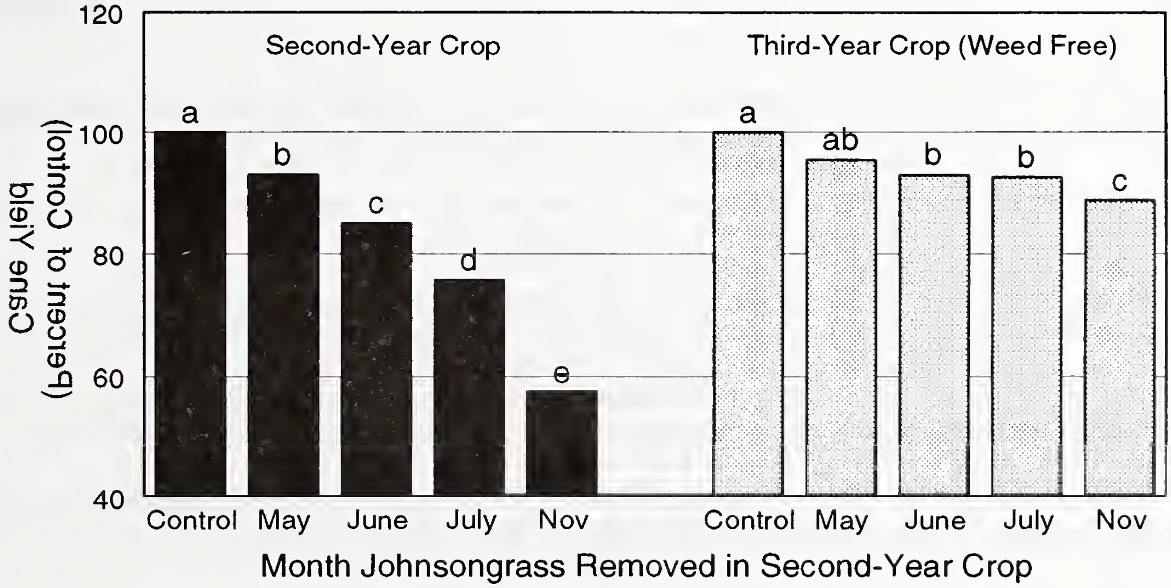

Figure 2. Effect of johnsongrass removal dates in the second-year crop (johnsongrass infestations began in the first year and continued into the second year) on subsequent cane yield in the second year and the following weed-free third year. Bars within a crop year with the same letter are not significantly different (LSD, $P=0.05$).

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FALLOW AND SUCCESSIVE PLANTING EFFECTS ON SUGARCANE YIELDS IN FLORIDA

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ABSTRACT

Sugarcane growers in Florida have changed from a primarily fallow to a primarily successive planting system although no published research has compared the two planting systems under Florida conditions. The major objective of this research was to compare yields between sugarcane planted on fallow and successive fields. Additional objectives were to determine to what extent the later planting date of the successive system contributed to yield differences between the successive and fallow systems and to determine if cultivars interacted significantly between the two systems. Results were based on four plant-crop harvests, two first-ratoon harvests, and one second-ratoon harvest from field experiments at four locations. Sugarcane planted in the fallow system had significantly greater sugar yields per acre than sugarcane planted in the successive system. These significant differences occurred in both the plant-crop and ratoon harvests, although the magnitude of the differences declined with each subsequent ratoon harvest. The later planting date of the successive compared to the fallow system did not account for most of the yield difference between the two systems. No cultivar consistently yielded well in the successive system across locations. Future research should examine reasons for the lack of consistent cultivar performance with the successive system, such as changed nutritional needs, or accumulations of pathogens, insects, weeds, or nematodes that do not occur with fallow planting.

INTRODUCTION

Florida sugarcane growers have two general planting systems, successive and fallow. In the successive system, growers plant sugarcane from 2 weeks to 3 months after a final-ratoon sugarcane harvest. In the fallow system, growers do not plant sugarcane during the 8 to 12 months between a final-ratoon sugarcane harvest and the next sugarcane planting. Growers leave the land idle or grow other crops during these 8 to 12 months. When they grow other crops, the land remains idle for at least 4 months, mostly during the summer, hence the system becomes a summer fallow. Planting in the fallow system may begin in August, whereas successive planting does not begin until after the October harvest season starts.

Published records are not available, but until about 1980, most sugarcane in Florida was planted in a fallow system. Since 1980, successive planting of sugarcane increased, and now most Florida sugarcane is planted in the successive rather than a fallow system. Estimates of fallow and successive sugarcane in Florida began in 1987 when 57.4% was fallow and 42.6% was successive (Glaz and Coale, 1987). By 1993, the ratio had changed to 32.3% fallow and 67.6% successive (Glaz, 1994). In 1994, the trend reversed as fallow comprised 36.5% and successive 63.5% of the sugarcane planted in Florida (Glaz, 1995).

Prior to the research reported here, no experimental results comparing yields from successive and fallow planting in Florida were available. However, most growers agreed that plant-crop yields of the successive system were lower than plant-crop yields from fallow systems. Growers did not have clear expectations of ratoon yields from the different cropping systems. Even with the lower plant-crop production, many growers favored the successive system because it allowed them to harvest sugarcane from the same field annually. In a fallow system, a grower who harvests from the plant through the second-ratoon crop only harvests sugarcane from a field 3 out of every 4 years.

In an economic analysis of several production practices in Louisiana, Johnson et al. (1993) concluded that more use of successive planting would increase the economic efficiency of sugarcane production. Arceneaux and Ricaud (1990) found that yields with successive sugarcane in Louisiana were more responsive to increased levels of N, P, and K fertilizers than sugarcane in a fallow system. In an earlier experiment in Louisiana, Ricaud and Arceneaux (1988) reported higher cane tonnages from fallow compared to successive sugarcane in the plant crop but no significant differences in sugar yield for both the plant and first-ratoon crop and for cane yield in the first-ratoon crop.

The major objective of this research was to compare yield differences from the plant-crop through the second-ratoon harvests of sugarcane planted in fallow and successive systems. Other objectives were to determine to what extent the later planting date of the successive system contributed to yield differences between the successive and fallow systems, and to determine if cultivars interacted significantly with fallow and successive systems.

MATERIALS AND METHODS

Four sugarcane experiments were planted on organic soils (Histosols) in Florida from 1987 through 1990. The soils at locations 1 and 4 were Pahokee mucks (euic, hyperthermic Lithic Medisaprists), and at locations 2 and 3 they were Terra Ceia mucks (euic, hyperthermic Typic Medisaprists). Table 1 shows soil characteristics, planting date, and harvest date(s) at each location. The Section, Township, and Range, respectively, of each location were: location 1: 10,43,38; location 2: 4,43,38; location 3: 1,42,38; and location 4: 5,43,37. The experiment at location 3 was harvested three times, from the plant crop through the second-ratoon crop. The experiment at location 4 was harvested in the plant and first-ratoon crops, and the experiments at locations 1 and 2 were harvested only in the plant crop.

Each experiment was a two-treatment factorial with three replications in a randomized complete-block design with treatments arranged as split plots. Three planting systems comprised the main plots, regular fallow planting (RFP), late fallow planting (LFP), and successive planting (SP). Late fallow planting was the same as RFP, except that LFP occurred on the same date as SP. Sugarcane cultivars comprised the subplots. Either four or six cultivars, with no cultivar common to all locations, were planted in each experiment. Each experimental unit was four rows wide with 5 ft between rows and 30 ft long. Each experimental unit was buffered on the end by a 5 ft alley and on the side by a 10-ft alley.

The most practical procedure to establish plots planted on land prepared by fallow and successive methods was to use separate fields. To minimize the effects of lack of randomization for these main plot treatments, locations were chosen as described to minimize variation from sources other than treatments. Each location had two commercial fields separated only by a field ditch. Prior to planting, the field on one side of the ditch had standing sugarcane scheduled for its final-ratoon harvest, and the field on the other side of the ditch had not been cropped with sugarcane since its most recent sugarcane harvest 8-12 months earlier. Field pairs had similar yield histories, and received fertilizer treatments according to their soil test values. Thus, at each location, all RFP and LFP main plots were on one side of the field ditch and all SP main plots were on the other side. Otherwise, all treatments were randomized.

At locations 1 and 4, the RFP and LFP plots had been fallow since their previous last-ratoon sugarcane harvest. At location 2, the RFP and LFP plots were preceded by a crop of sweet corn (*Zea mays* L.) and then a fallow period preceding this experiment. Location 3 was similar to location 2, except that it was flooded for 40 days of its fallow period.

At each harvest, laborers cut and piled all four rows of cane from each subplot. This cane was weighed with a tractor-mounted weighing device, and cane yield, measured as tons cane per acre (TCA), was calculated from this weight. Fifteen full-length stalks randomly selected from each subplot comprised the samples used for milling and crusher juice analysis. The theoretical sugar concentration, measured as lb sugar per ton of cane, was calculated from the Brix and polarity of each sample using a previously described procedure (Arceneaux, 1935). The product of cane yield x sugar concentration equaled sugar yield, measured as lbs sugar per acre.

Analyses of variance were calculated with MSTAT-C (Freed et al., 1988) for each location separately. Significant F and unprotected LSD values were sought at $P \leq 0.05$.

RESULTS AND DISCUSSION

The mean cane yield from the plant crop of all four locations for SP was significantly lower than for either RFP or LFP (Table 2). The cane yields for SP at locations 2, 3, and 4 were also significantly less than the cane yields for RFP or LFP, and the SP cane yield at location 1 was significantly less than the RFP cane yield. The four-location mean plant-crop cane yield from RFP was greater but not significantly different from that of LFP. Similarly, the LFP cane yield at each location was less than, but not significantly different from, its corresponding RFP cane yield.

The only treatment difference between RFP and LFP was date of planting, with LFP at each location planted after RFP (Table 1). Since differences in yield between RFP and LFP were not significant, we cannot claim at $P = 0.05$ that the later planting date was partially responsible for the significantly lower yields reported with SP. However, differences in cane yield between RFP and LFP were consistent across locations, averaging 4.31 TCA and ranging from 2.98 TCA at location 2 to 5.91 TCA at location 4 (Table 2). Therefore, for the mean plant-crop yield difference of 14.54 TCA between RFP and SP, a reasonable estimate is 4.31 TCA, or 29.6% of the difference between RFP and SP, was due to planting date. Again, although this yield difference was not statistically significant, due to its consistent nature, it appears that a reasonable estimate is that about 29.6% of the difference in cane yields between RFP and SP may be due to the later planting date of successive planting.

Within each location, differences in planting of LFP or SP with RFP varied from 28 days at location 3 to 100 days at location 1 (Table 1). However, linear or quadratic regression showed no relationship between number of days between planting and yields of RFP with LFP or RFP with SP (data not shown).

Differences due to planting system in sugar concentration occurred in the plant crop at some locations (Table 2). At location 1, sugar concentration of SP was significantly greater than that of LFP and almost significantly greater than that of RFP ($P = 0.09$). At location 4, SP yielded significantly less sugar concentration than RFP or LFP. Since the fallow treatments at locations 1 and 4 were subjected to identical conditions preceding this experiment, a fallow period with no other crop after the previous sugarcane harvest, these differences in sugar concentration are not explainable.

At location 2, the fallow treatments in this experiment were preceded by a crop of sweet corn. Location 3 was similar, except that after the sweet corn was harvested, the soil was flooded for 40 days. At location 2, planting systems caused no significant differences in sugar concentration. This is consistent with Glaz and Ulloa (1994) who reported no changes in sugar concentrations of sugarcane due to previous phosphorous fertilizers applied to sweet corn on moderate pH soils such as those of location 2 (Table 1). At location 3, the sugar concentration of SP was significantly greater than the sugar concentrations of both fallow planting treatments. The lower sugar concentrations in the sugarcane planted after sweet corn compared to the SP at location 3 are consistent with the conclusion of Glaz and Ulloa (1994) that the phosphorous applied to a previous crop of sweet corn causes reductions in sugar concentration on low pH soils such as those of location 3 (Table 1).

Alternate cropping practices, such as no alternate crop, sweet corn, or sweet corn followed by flood, and differences among soil pHs may have resulted in variable sugar concentrations across locations. However, significant treatment differences in cane yield and sugar yield were similar across locations and for overall location means, in spite of the differences in sugar concentrations at some locations (Table 2).

Cane yields, sugar concentrations and sugar yields of RFP and LFP were nearly identical in the ratoon harvests (Table 3) which indicates that planting date in the fallow system had no effect on ratoon yields. The mean cane yield of SP for both locations was significantly less than for the fallow plantings in the first-ratoon crop. However, the difference in cane yields between RFP and SP had dropped to 5.34 TCA at locations 3 and 4 in first ratoon compared to 16.99 TCA at locations 3 and 4 and 14.54 TCA at all four locations in the plant crop (Tables 2 and 3). Thus, as in the plant crop, SP resulted in lower cane yields than fallow planting in the first-ratoon crop, although the difference between the two planting systems was not as great in first ratoon as in the plant crop. The sugar concentrations of SP were significantly less than for either of the fallow planting treatments at both locations in first ratoon. For location 4, this is consistent with the plant-crop results, but it is a reversal of the plant-crop results at location 3 (Table 2). Based on Glaz and Ulloa (1994), we would have expected the sugar concentration of SP to remain higher than the sugar concentrations of the fallow plantings in first ratoon at location 3. Perhaps in the present study, since the fallow plots at location 3 had been flooded prior to planting, most of the negative effect on sugar concentration of the fertilizer used for the previous crop of sweet corn had dissipated. In the previous study by Glaz and Ulloa (1994), flooding after sweet corn was not tested. Another possibility is that the successive system itself causes reduced ratoon sugar concentrations. Due to greater cane yields (significantly greater at location 3 and at $P = 0.11$ at location 4) and sugar concentrations, both fallow planting treatments had significantly greater sugar yields than SP at both locations with first-ratoon harvests.

At location 3, the only site where we obtained second-ratoon yield information, there were no significant differences for cane yield or sugar concentration among the planting treatments (Table 3). However, due to the combined nonsignificant differences in cane yield and sugar concentration, the sugar yield of RFP was significantly greater than that of SP (Table 3). Thus, sugar yield for RFP was significantly greater than for SP from the plant crop through the second-ratoon crop at location 3. The mean difference in sugar yield between RFP and SP across locations was 3,482 lb sugar per acre in the plant crop (all four locations), 1,768 lb per acre in the first-ratoon crop (locations 3 and 4), and 618 lb per acre in the second-ratoon crop (location

3). For the 3-year period, RFP yielded 5,868 lb sugar per acre more than SP. Of the 5,868 lb per acre difference, only 1,290 lb per acre or 22% were attributable to planting date. Thus, yields from SP were much lower than from fallow planted sugarcane, and although the later planting date of SP may have accounted for some of this loss, it was not significant at $P = 0.05$. Regardless of the effect of planting date on yield, other unexplained factors contributed to the lower SP yields.

Cultivar Adaptation to Fallow Planting at Different Dates

Cultivars interacted significantly with planting systems for most yield characteristics at all locations. Since the same cultivars were not planted at all locations, means were presented previously to serve as an estimate of Florida mean yields under fallow and successive planting. However, the significant interactions imply that some cultivars may be better suited to a particular planting system. Since classification of cultivars according to this characteristic could help growers improve yields with both fallow and successive planting, a detailed summary of these cultivar x planting system interactions is provided.

At location 1, CP 80-1827 yielded significantly more cane yield and sugar yield than the other cultivars with RFP (Table 4). The cane yields, sugar concentrations, and sugar yields of CP 78-2114 and CP 80-1827 were not significantly different from each other with LFP, but their sugar yields were significantly greater with LFP than the sugar yields of the other two cultivars. Thus, CP 78-2114 and CP 80-1827 were good choices for LFP. Among the four cultivars tested at location 1, CP 78-2114 had the least loss in sugar yield due to the later fallow planting date. CP 80-1827 did not have outstanding yields at location 2 in either of the fallow planting systems (Table 5). Conversely, at location 3, CP 80-1827 was the best choice for LFP and as productive as any of the other cultivars with RFP (Table 6). CP 78-2114, the outstanding LFP cultivar at location 1, was also tested at location 4 where its performance reversed. At location 4, it was the only cultivar whose sugar yield for LFP was significantly less than its sugar yield for RFP (Table 7). Thus, at one location, CP 78-2114 was the cultivar least negatively affected by the later fallow planting date, whereas at a second location, CP 78-2114 was the cultivar most negatively affected due to a later fallow planting date.

The sugar yield of CL 61-620 was significantly greater than the sugar yields of all cultivars except CL 69-886 with RFP at location 2 (Table 5). It also had significantly more sugar yield than any cultivar except CP 72-2086 for the LFP treatment at location 2. CL 61-620 was also tested at location 4 where it had high yields under both fallow planting systems (Table 7). For cultivars tested at more than one location, CL 61-620 was the only cultivar that had high sugar yield consistently at all locations tested with fallow planting, regardless of planting date. CP 72-2086 and CP 80-1827 were each tested at three locations and had high sugar yield regardless of planting date, with fallow planting, at two of the three locations (Tables 4-7).

Cultivar Adaptation to Successive Planting

At location 1, CP 80-1827 was a high yielding cultivar regardless of planting system, although its sugar concentration and sugar yield relative to RFP declined substantially with SP (Table 4). At location 2, CP 80-1827 had high yields with SP and was the only cultivar in SP to yield significantly more sugar yield than CL 61-620 and CP 72-2086. As stated previously, CL 61-620 had high sugar yields in the fallow plantings at location 2 (Table 5). Therefore, at location 2, CP 80-1827 was well adapted to SP relative to other cultivars. At location 3, the reverse was true of CP 80-1827, it yielded poorly in SP compared to its LFP yields relative to other cultivars. This was reflected by the sugar yield of CP 80-1827 being significantly greater than that of CP 72-2086 in LFP and significantly lower than that of CP 72-2086 in SP (Table 6).

CP 78-2114 had a high sugar yield in SP at location 1 (Table 4). The sugar yield of CP 78-2114 was significantly lower than that of CP 80-1827 in RFP but the sugar yields of the two cultivars were not significantly different in SP (Table 4). These yields at location 1 would have identified CP 78-2114 as well adapted to SP except that at location 4, CP 78-2114 ranked in the highest group of cultivars for sugar yield in RFP, but had significantly less sugar yield than CL 61-620 and CL 72-321 in SP (Table 7). Therefore, at location 4, CP 78-2114 was classified as poorly adapted to SP. CP 72-2086 had significantly more sugar yield in SP than all other cultivars at location 3 (Table 6), but had significantly lower sugar yields with SP than at least one other cultivar at locations 2 and 4 with SP (Tables 5 and 7).

One objective of this study was to identify cultivars that yield well with successive planting. As the preceding summary shows, no cultivar consistently yielded well with successive planting across locations. Thus, increased understanding of cultivar interaction with planting system would probably help improve yields with SP. Perhaps the previous cultivar grown in a particular field affects cultivar performance under SP. This may be related to accumulations of weeds, soil insects, pathogens, or nematodes that may affect some cultivars more than others. Also, as shown by Arceneaux and Ricaud (1990) in Louisiana, SP may need increased levels of certain nutrients to yield as well as RFP.

Growers should consider non-sugarcane uses of their land made possible with fallow planting when comparing the merits of fallow and successive planting. Two such uses during the fallow period are growing crops of sweet corn (Glaz and Ulloa, 1994) and, or rice (Snyder et al., 1986). In addition, the fallow system provides growers with the opportunity to flood land for extended periods during the summer months. Flooding adds the additional benefit of reducing subsidence of organic soils which could add to the longevity of sugarcane production on organic soils in Florida and contribute positively to the ecosystem of South Florida.

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Table 1. Soil types, soil pH's, planting dates, and harvest dates of four experiments comparing effects of planting systems and clones on sugarcane yields.

			Planting date		Harvest date		
Location	Soil Type	Soil pH	RFP	SP and LFP	Plant crop	First ratoon	Second ratoon
1	Pahokee muck	7.9	08 Oct 87	16 Jan 88	11 Mar 89	N/A	N/A
2	Terra ceia muck	6.7	04 Nov 89	16 Dec 89	03 Apr 91	N/A	N/A
3	Terra ceia muck	5.3	04 Dec 89	01 Jan 90	15 Mar 91	04 Feb 92	8 Nov 92
4	Pahokee muck	5.6	20 Oct 90	22 Nov 90	29 Feb 92	15 Mar 93	N/A

Table 2. Plant-crop cane and sugar yields of three sugarcane planting systems at four locations.

Location	Planting system	Cane yield	Sugar concentration	Sugar yield
		tons/acre	lbs/ton	lbs/acre
1	Regular fallow	44.84	251	11,264
1	Late fallow	40.01	239	9,566
1	Successive	34.63	262	9,076
1	LSD (0.05)	9.11	13	2,478
2	Regular fallow	70.86	253	17,927
2	Late fallow	67.88	256	17,391
2	Successive	58.54	253	14,816
2	LSD (0.05)	6.80	9	2,094
3	Regular fallow	88.61	227	20,159
3	Late fallow	85.57	224	19,202
3	Successive	73.62	245	18,044
3	LSD (0.05)	6.75	9	1,103
4	Regular fallow	82.29	261	21,519
4	Late fallow	76.38	263	20,073
4	Successive	63.31	251	15,865
4	LSD (0.05)	6.14	4	1,491
Mean	Regular fallow	72.73	250	18,175
Mean	Late fallow	68.42	248	16,968
Mean	Successive	58.19	253	14,693
Mean	LSD (0.05)	6.70	6	1,586

Table 3. Ratoon cane and sugar yields of three sugarcane planting systems at two locations.

Crop	Location	Planting system	Cane yield	Sugar Concentration	Sugar yield
			tons/acre	lbs/ton	lbs/acre
1R[†]	3	Regular fallow	76.72	252	19,356
1R	3	Late fallow	77.94	254	19,766
1R	3	Successive	69.25	243	16,828
1R	3	LSD (0.05)	2.85	9	543
1R	4	Regular fallow	56.68	259	14,708
1R	4	Late fallow	56.34	262	14,744
1R	4	Successive	52.76	255	13,433
1R	4	LSD (0.05)	4.85	3	1,358
1R	Mean	Regular fallow	64.70	257	16,602
1R	Mean	Late fallow	64.98	258	16,797
1R	Mean	Successive	59.36	250	14,834
1R	Mean	LSD (0.05)	3.67	4	887
2R[†]	3	Regular fallow	58.97	260	15,338
2R	3	Late fallow	59.34	254	15,060
2R	3	Successive	57.50	256	14,720
2R	3	LSD (0.05)	2.03	9	525

[†] 1R = first ratoon and 2R = second ratoon.

Table 4. Plant-crop cane and sugar yields of four sugarcane cultivars in three planting systems at location 1.

Clone	Planting system[†]	Cane yield		Sugar concentration		Sugar yield	
		tons per acre	% of RFP	lbs per ton	% of RFP	lbs per acre	% of RFP
CP 72-1210	RFP	46.36		253		11,717	
CP 78-1247	RFP	34.07		237		8,073	
CP 78-2114	RFP	46.37		254		11,795	
CP 80-1827	RFP	52.58		261		13,717	
CP 72-1210	LFP	36.24	78.2	242	95.6	8,765	74.8
CP 78-1247	LFP	28.07	82.4	228	96.2	6,391	79.2
CP 78-2114	LFP	46.21	99.6	244	96.1	11,295	95.8
CP 80-1827	LFP	49.51	94.2	242	92.7	11,995	87.4
CP 72-1210	SP	29.28	63.1	263	103.9	7,697	65.7
CP 78-1247	SP	27.40	80.4	263	111.0	7,214	89.3
CP 78-2114	SP	37.65	81.2	270	106.3	10,155	86.1
CP 80-1827	SP	44.20	84.1	252	96.5	11,155	81.3
LSD (0.05)		5.24		17		1,040	

[†] RFP = Regular fallow planting, LFP = Late fallow planting, and SP = Successive planting.

Table 5. Plant-crop cane and sugar yields of five sugarcane cultivars in three planting systems at location 2.

Clone	Planting system[†]	Cane yield		Sugar concentration		Sugar yield	
		tons per acre	% of RFP	lbs per ton	% of RFP	lbs per acre	% of RFP
CL 61-620	RFP	74.95		260		19,508	
CL 69-886	RFP	73.68		250		18,424	
CL 73-239	RFP	63.15		262		16,520	
CP 72-2086	RFP	69.98		251		17,564	
CP 80-1827	RFP	72.58		242		17,575	
CL 61-620	LFP	70.12	93.5	272	104.6	19,043	97.6
CL 69-886	LFP	71.01	96.4	245	98.0	17,419	94.5
CL 73-239	LFP	62.81	99.5	270	103.0	16,953	102.6
CP 72-2086	LFP	69.02	98.6	257	102.4	17,738	101.0
CP 80-1827	LFP	66.43	91.5	237	97.9	15,744	89.6
CL 61-620	SP	52.65	70.2	263	101.1	13,867	71.1
CL 69-886	SP	61.61	83.6	249	99.6	15,326	83.2
CL 73-239	SP	54.83	86.8	271	103.4	14,846	89.9
CP 72-2086	SP	55.30	79.0	250	99.6	13,815	78.6
CP 80-1827	SP	68.33	94.1	233	96.3	15,908	90.5
LSD (0.05)		4.26		15		1,543	

[†] RFP = Regular fallow planting, LFP = Late fallow planting, and SP = Successive planting.

Table 6. Mean of plant-crop through second-ratoon cane and sugar yields of four sugarcane cultivars in three planting systems at location 3.

Clone	Planting system[†]	Cane yield		Sugar concentration		Sugar yield	
		tons per acre	% of RFP	lbs per ton	% of RFP	lbs per acre	% of RFP
CL 73-239	RFP	61.95		269		16,660	
CP 70-1133	RFP	82.21		229		18,792	
CP 72-2086	RFP	78.25		245		19,171	
CP 80-1827	RFP	76.67		244		18,703	
CL 73-239	LFP	59.35	95.8	264	98.1	15,656	94.0
CP 70-1133	LFP	81.84	99.5	228	99.6	18,683	99.4
CP 72-2086	LFP	76.17	97.3	241	98.4	18,367	95.8
CP 80-1827	LFP	79.78	104.1	243	99.6	19,357	103.5
CL 73-239	SP	55.81	90.1	260	96.6	14,497	87.0
CP 70-1133	SP	71.19	86.6	235	102.6	16,728	89.0
CP 72-2086	SP	71.45	91.3	251	102.4	17,932	93.5
CP 80-1827	SP	68.72	89.6	246	100.8	16,930	90.5
LSD (0.05)		2.80		7		968	

[†] RFP = Regular fallow planting, LFP = Late fallow planting, and SP = Successive planting.

Table 7. Mean of plant crop and first-ratoon cane and sugar yields of six sugarcane cultivars in three planting systems at location 4.

Clone	Planting system†	Cane yield		Sugar concentration		Sugar yield	
		tons per acre	% of RFP	lbs per ton	% of RFP	lbs per acre	% of RFP
CL 61-620	RFP	75.65		256		19,348	
CL 69-886	RFP	61.11		255		15,609	
CL 72-321	RFP	67.11		266		17,874	
CP 72-1210	RFP	65.69		260		17,067	
CP 72-2086	RFP	76.34		262		19,978	
CP 78-2114	RFP	71.03		264		18,737	
CL 61-620	LFP	73.02	96.5	259	101.2	18,938	97.9
CL 69-886	LFP	61.26	100.2	258	101.2	15,830	101.4
CL 72-321	LFP	67.65	100.8	264	99.2	17,831	99.8
CP 72-1210	LFP	61.80	94.1	261	100.4	16,135	94.5
CP 72-2086	LFP	73.44	96.2	266	101.5	19,510	97.7
CP 78-2114	LFP	60.99	85.9	265	100.4	16,194	86.4
CL 61-620	SP	67.46	89.2	256	100.0	17,257	89.2
CL 69-886	SP	53.23	87.1	242	94.9	12,884	82.5
CL 72-321	SP	62.25	94.8	255	98.1	15,875	88.8
CP 72-1210	SP	53.21	81.0	244	93.8	12,963	75.9
CP 72-2086	SP	59.88	78.4	255	97.3	15,279	76.5
CP 78-2114	SP	52.20	73.5	264	100.0	13,774	73.5
LSD (0.05)		5.79		9		1,593	

†RFP = Regular fallow planting, LFP = Late fallow planting, and SP = Successive planting.

CHANGES IN LEAF SCALD INCIDENCE IN THE CANAL POINT SUGARCANE CULTIVAR DEVELOPMENT PROGRAM IN FLORIDA: 1987-1993

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ABSTRACT

This paper documents the increased incidence of leaf scald among important parental clones and progeny of the CP-cultivar development program between 1987 and 1993. The incidence of leaf scald among naturally-infected Stage II clones in the Canal Point sugarcane cultivar development program averaged less than 1% between 1967, the year it was first detected, and 1987. Between 1989 and 1993, the average incidence of leaf scald increased dramatically to 15.1%. The incidence of infected progeny was influenced by parental clone and year. In 1989, the incidence of infection of progeny in Stage II ranged from 0 to 50% depending on their parents. Subsequent years had similar ranges. The overall incidence of infection was highest in 1991. The disease has caused many Stage II clones to be eliminated from the program since 1989. Parental clones that gave rise to high frequencies of leaf scald susceptible progeny have been either discontinued or crossed only with resistant clones. The use of parental clones that transmit a high level of leaf scald resistance to their progeny would improve the efficiency of the breeding program by reducing the number of selections needed to provide the required number of resistant cultivars for replicated yield tests. The availability of resistant cultivars would also reduce the threat of leaf scald in commercial sugarcane production. A change in the pathogen, *Xanthomonas albilineans*, is suspected to have occurred in the late 1980's that resulted in the increased leaf scald incidence.

INTRODUCTION

Leaf scald of sugarcane, caused by *Xanthomonas albilineans* (Ashby) Dowson, was first reported in Florida in 1967 (Koike, 1968). Although leaf scald is considered a major disease problem in many sugarcane producing countries (Ricaud and Ryan, 1989), the incidence of leaf scald remained very low in Florida until 1987. Since then, the incidence of leaf scald has increased rapidly at the USDA-ARS Sugarcane Field Station at Canal Point and in commercial fields in Florida. An initial report of the increased occurrence was published in 1992 (Comstock and Shine, 1992). The purpose of this paper is to document the increased incidence of leaf scald among important parental clones and progeny of the CP-cultivar development program between 1987 and 1993. Further, the responses made to the increased leaf scald incidence and factors that will influence the future levels of leaf scald in the cultivar development program at the Canal Point Sugarcane Field Station are discussed.

MATERIALS AND METHODS

Multiple surveys were made for leaf scald among clones in Stage II (non-replicated clone trials) of the cultivar development program for leaf scald throughout the growing season of 1987, and the seasons of 1989 through 1993. Each clone, advanced from a single stool in Stage I, occupied a single plot in Stage II. Plot size was two rows by 5 m. There were 1,057 clones in 1987, 1,053 in 1989, 1,207 in 1990, 759 in 1991, 1,418 in 1992, and 907 in 1993. The incidence of leaf scald was a result of natural infection. A clone was counted as infected when the following characteristic symptoms were observed on one or more stalks in its plot: pencil-line leaf streaks, chlorotic leaf streaks with or without necrosis, profuse side shoot development on mature stalks, and/or necrosis and wilting of upper leaves which appear stiff and curl inward at the tips (Ricaud and Ryan, 1989). Infection was verified initially by isolation of the pathogen, *X. albilineans*, from symptomatic plants and confirmed by colony characteristics and serological assays in some cases (Comstock and Irey, 1992); later identification was based entirely on symptoms.

The incidence of leaf scald was determined on a yearly basis for the entire group of clones in Stage II and for progeny of cultivars, CP 70-1133, CP 80-1827, and CP 81-1302. These specific cultivars had at least 50 progeny per year when used as either a male or a female parent. The percent progeny infection of other clones (Co 285, CP 70-1133, CP 72-1210, CP 72-2086, CP 75-1082, CP 77-1776, CP 78-1610, CP 78-1628, CP 80-1743, CP 80-1827, CP 81-1238, CP 81-1302, CP 81-1425, CP 81-2149, CP 82-1172, CP 82-1592, CP 82-2043, CP 83-1770, CP 84-1591, and SP 70-1143) was determined by combining data for all years for the period 1989 through 1993.

RESULTS AND DISCUSSION

A dramatic increase in leaf scald infection incidence of clones in Stage II occurred in 1989 when it reached 11.1%, a level much higher than the historic 1% levels of the 1970's and early 1980's (Figure 1). The incidence of infection remained high through the monitored period, with 1991 being the highest with 23.5% of all the clones is Stage II infected followed by lower levels in 1992 and 1993. The incidence of leaf scald in progeny of cultivars, CP 70-1133, CP 80-1827, and CP 81-1302, followed the same trend (Figure 2), peaking in 1991. A change in the pathogen is believed to be the major reason for the dramatic increase in leaf scald infection. A genetic difference between *X. albilineans* isolates collected after 1987 and those collected in the 1970's and 1980's has been reported (Davis, 1992). Davis (1992) proposed that a new strain of the pathogen was introduced into Florida. A sudden increase in susceptibility of Stage II clones does not appear likely because there was no dramatic shift in parental clones used in the breeding program during the period of the surveys.

The frequency of leaf scald infection ranged from 3.4% for progeny of Co 285 to 32.2% for progeny of CP 82-1172 (Table 1). Interestingly, three leaf scald resistant cultivars, CP 82-1172, CP 72-2086, and CP 70-1133, produced different frequencies of infection for their progeny. CP 82-1172 produced a very high proportion (32.2%) of progeny that became naturally infected with leaf scald. In contrast, CP 72-2086 had only 7.9% of its progeny naturally infected with leaf scald and CP 70-1133 had only 9.0%. Half the parental clones produced progeny that had an infection rate in a range of 12 to 19%.

Observations suggest that once the frequency of infection is obtained on a population of 50 or more clones, the infection frequency can be used in prediction of how well the parental clones transmit leaf scald resistance to their progeny. This information is useful in determining which clones to use as parents to increase the frequency of resistant progeny. The biparental cross, CP 83-1770 x CP 82-1172, (Table 2) that resulted in 5 of 14 progeny infected (35.7%) might not have been made if it had been known that both parental clones give rise to high frequency of leaf scald susceptible progeny. Another biparental cross, Co 285 x CP 72-2086, had only 3.8% progeny infected. Both parents had a prior history of relatively low levels of leaf scald infection in their progeny (Table 1). The frequency of leaf scald infection of progeny for 3 other biparental crosses, CP 84-1591 x SP 70-1143, CP 70-1133 x CP 72-2086, and CP 82-

2043 x CP 70-1133, that reached Stage II in 1993 also fell in the expected range.

One method of controlling leaf scald is the use of more resistant and diverse sugarcane clones as parents in cultivar development programs. The use of parental clones that transmit a high level of leaf scald resistance to their progeny would improve the efficiency of the breeding program by reducing the number of selections needed to provide the required number of resistant clones for replicated yield tests. The availability of resistant cultivars would also reduce the threat of leaf scald in commercial sugarcane production.

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Table 1. Frequency of leaf scald infection in progeny by parental clone*.

Parental clone	No. of progeny	Infected (%)
Co 285	58	3.4
CP 70-1133	433	9.0
CP 72-1210	219	13.2
CP 72-2086	242	7.9
CP 75-1082	65	9.2
CP 77-1776	103	19.1
CP 78-1610	138	9.4
CP 78-1628	70	4.2
CP 80-1743	115	27.8
CP 80-1827	562	16.2
CP 81-1238	218	13.3
CP 81-1302	386	15.3
CP 81-1425	229	17.0
CP 81-2149	350	17.1
CP 82-1172	87	32.2
CP 82-1592	114	8.0
CP 82-2043	267	12.0
CP 83-1770	209	18.1
CP 84-1591	187	17.6
SP 70-1143	24	17.6

*Stage II, 1989-1993, Parental clone used as either male or female.

Table 2. Frequency of leaf scald infection in progeny of biparental crosses*.

Parentage			No. of Infected progeny	(%)
CP 83-1770	x	CP 82-1172	14	35.7
(18.1)[a]		(32.2)		
CP 84-1591	x	SP 70-1143	49	14.3
(17.6)		(17.6)		
Co 285	x	CP 72-2086	53	3.8
(3.4)		(7.9)		
CP 70-1133	x	CP 72-2086	25	8.0
(9.0)		(7.9)		
CP 82-2043	x	CP 70-1133	36	13.9
(15.3)		(9.0)		

*Stage II, 1993

[a] Number in () is the % infection for all progeny of clone during 1989-1993.

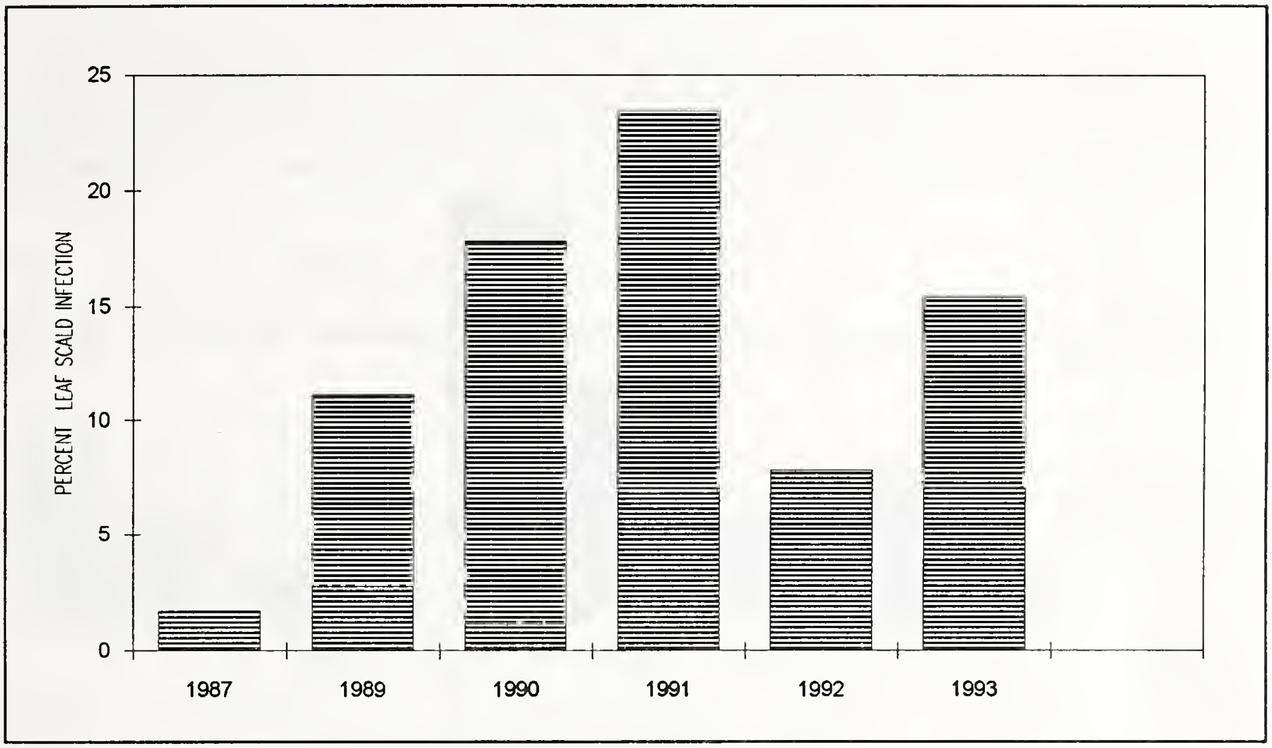

Figure 1. Leaf scald (LS) incidence of clones in Stage II of the Canal Point (CP) cultivar development program from 1987 to 1993.

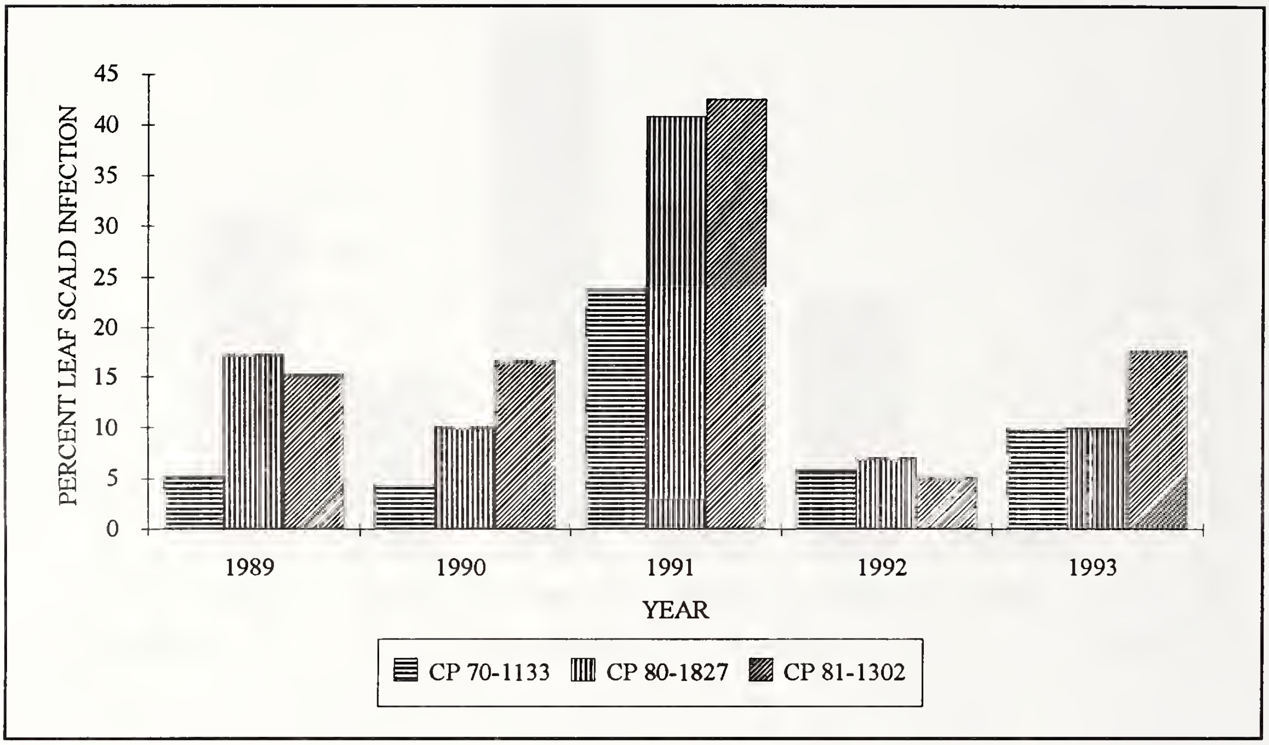

Figure 2. Leaf scald (LS) incidence of progeny of parental clones, CP 70-1133, CP 80-1827, and CP 81-1302 from 1989 to 1993.

CULTIVAR RELEASES

NEW CULTIVAR--FLORIDA

CP 85-1308

P.Y.P. Tai, J.D. Miller, C.W. Deren, B. Glaz, J.M. Shine, Jr., and J.C. Comstock

Developed by: Cooperative program comprised of USDA-ARS at Canal Point, Florida Sugar Cane League, Inc. at Clewiston, and University of Florida, IFAS at Gainesville released CP 85-1308 in 1993.

Parents: R 567 x CP 74-2013

Reactions to Insects and Diseases: CP 85-1308 has moderate levels of rust and low levels of leaf scald.

Percentage Fiber: 9.70

Other Information: CP 85-1308 was tested at 9 locations from the plant-cane through the second-ratoon crops. Its yield data are compared to the commercial reference cultivar, CP 70-1133, in the table that follows. CP 85-1308 yielded well on muck and sand soils.

Cultivar	Crop	Stalk #	Stalk Wt.	Theroetical Recoverable Sugar	Cane yield	Sugar yield
		#/acre	lbs	lbs/ton	------tons/acre-----	
CP 85-1308	PC	41,119	3.1	184.0	64.34	5.919
CP 85-1308	R1	32,487	3.7	237.0	60.68	7.191
CP 85-1308	R2	32,137	3.1	237.1	50.69	6.010
CP 85-1308	Mean	35,497	3.3	219.4	58.57	6.425
CP 70-1133	PC	44,757	2.8	185.2	63.67	5.897
CP 70-1133	R1	35,030	3.2	216.5	56.28	6.094
CP 70-1133	R2	34,859	2.8	224.3	48.99	5.495
CP 70-1133	Mean	38,834	2.9	208.7	56.31	5.876

NEW CULTIVAR--FLORIDA

CP 85-1382

B. Glaz, C.W. Deren, J.M. Shine, Jr., J.D. Miller,
P.Y.P. Tai, J.C. Comstock, and O. Sosa, Jr.

Developed by: Cooperative program comprised of USDA-ARS at Canal Point, Florida Sugar Cane League, Inc. at Clewiston, and University of Florida, IFAS at Gainesville released CP 85-1382 in 1993.

Parents: Female parent was CP 74-2005 and male was from Polycross 82 P 14.

Reactions to Insects and Diseases: An insect not previously found in Florida, the West Indian cane weevil, caused severe damage to several plantings of CP 85-1382 in 1994. CP 85-1382 has moderate levels of rust and low levels of leaf scald.

Percentage Fiber: 9.86

Other Information: CP 85-1382 was tested at 9 locations from the plant-cane through the second-ratoon crops. Its yield data are compared to the commercial reference cultivar, CP 70-1133, in the table that follows. Although it does not always remain erect, CP 85-1382 is more erect than most other Florida cultivars. Also, CP 85-1382 had outstanding tolerance to a severe freeze when it was harvested as plant cane. The freeze occurred at all nine locations in December, 1989.

Cultivar	Crop	Stalk #	Stalk Wt.	Theoretical Recoverable Sugar	Cane yield	Sugar yield
		#/acre	lbs	lbs/ton	------tons/acre-----	
CP 85-1382	PC	32,871	3.4	220.3	55.88	6.155
CP 85-1382	R1	30,350	4.0	237.3	60.70	7.201
CP 85-1382	R2	31,606	3.2	241.7	50.57	6.111
CP 85-1382	Mean	31,840	3.5	233.1	55.72	6.494
CP 70-1133	PC	44,757	2.8	185.2	63.67	5.897
CP 70-1133	R1	35,030	3.2	216.5	56.28	6.094
CP 70-1133	R2	34,859	2.8	224.3	48.99	5.495
CP 70-1133	Mean	38,834	2.9	208.7	56.31	5.876

NEW CULTIVAR--FLORIDA

CP 86-1633

C.W. Deren, B. Glaz, J.M. Shine, Jr., P.Y.P. Tai, J.D. Miller, and J.C. Comstock

Developed by: Cooperative program comprised of USDA-ARS at Canal Point, Florida Sugar Cane League, Inc. at Clewiston, and University of Florida, IFAS at Gainesville released CP 86-1633 in 1993.

Parents: CP 75-1082 x CP 78-1140

Reactions to Insects and Diseases: CP 85-1633 has shown no insect or disease susceptibility.

Percentage Fiber: 11.15

Other Information: CP 85-1633 was tested at 7 locations with muck soils. Its yield data are compared to the commercial reference cultivar, CP 70-1133, in the table that follows. CP 85-1633 was not tested on sand soils.

Cultivar	Crop	Stalk #	Stalk Wt.	Theoretical Recoverable Sugar	Cane yield	Sugar yield
		#/acre	lbs	lbs/ton	------tons/acre-----	
CP 85-1633	PC	32,326	4.6	207.8	74.35	7.725
CP 85-1633	R1	32,088	3.4	223.4	54.55	6.093
CP 85-1633	R2	33,331	2.6	215.6	43.33	4.671
CP 85-1633	Mean	32,806	3.5	215.7	57.41	6.192
CP 70-1133	PC	38,353	3.8	214.6	72.87	7.819
CP 70-1133	R1	33,869	3.2	220.6	54.19	5.977
CP 70-1133	R2	36,000	2.4	226.2	43.20	4.886
CP 70-1133	Mean	36,329	3.1	208.7	56.31	5.876

AGRICULTURAL ABSTRACTS

The Role of BMP Education in the EAA Regulatory Effort

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As a result of the Everglades Protection Act of 1991 and the subsequent Rule making process (Chapter 40E-63, F.A.C.) by the South Florida Water Management District (SFWMD), water discharged from the Everglades Agricultural Area (EAA) basin is subject to a phosphorous (P) reduction goal. The overall Everglades Restoration goal is to reduce total P by 80% compared to the baseline years 1978-88. Twenty-five percent of this reduction is required through on-farm best-management practices (BMPs) by May 1, 1996. To obtain the required permit to discharge water from a production area to works-of-the-district, each permitted had to install water-quality sampling and flow-measuring devices, and implement a BMP plan. These BMPs are generally recognized as measures that, if adopted, would result in lower P levels in discharge water. BMP categories included water management, fertility, and sediment control. For example, fertility BMPs might include soil testing, fertilizer banding, slow release fertilizer forms, and spill prevention. While many of the BMPs, such as soil testing, were already common practices, the consistency of these practices has improved. Others, such as modified pumping practices, are new and have proven to be fairly intensive to implement. Eighty-one permits were issued covering approximately 310 privately owned drainage discharge structures draining 505,000 acres. Through a strong educational effort on the part of the Florida Sugar Cane league, the University of Florida Cooperative Extension Service, and the SFWMD, and a proactive and conscientious effort on the part of the agriculture industry to reduce P input, the following results have been achieved: 1. One hundred percent of the EAA basin is under drainage permits. 2. Basin-wide P-loading reductions are 3-5 years ahead of schedule. 3. Basin-wide P-loading has been reduced by more than 40%. This is 60% greater than the regulatory program goal.

Historical and Recent Evidence of Phosphorous Fertilization for Sugarcane Production in Florida

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Sugarcane in Florida is produced mainly on organic soils located in the Everglades Agricultural Area (EAA). Since 1929, researchers have reported that phosphorous (P) generally increased sugarcane production. Phosphorous recommendation for sugarcane in the EAA was established in 1974, and without change, it is still in use by growers today. Only four sites were utilized in developing this recommendation. At the present moment, calibration enhancement of this recommendation can be accomplished using information from 14 additional sites, consisting of 45 cropping years of data (1968-1991). Preliminary results indicate that only 25% of total sites responded to P application for the plant-cane crop, 50% for the first-ratoon cane crop, and 67% for the second-ratoon cane crop, and 100% for the third-ratoon cane crop. The results indicate the maintenance of long-term soil fertility extending to the fourth crop, is essential to reduce the likelihood of yield decline.

Relationship Between Soil Nutrient Analyses and Whole Farm Sugarcane Yields

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Fertilizer recommendations for sugarcane (*Saccharum* spp.) in Louisiana are based on soil calibration data derived from numerous soil fertility studies across years and locations. However, the correlation between soil analyses and sugarcane yield response to fertilizer application in Louisiana using soil calibration has traditionally been low (r^2 values of 0.35 or less). This indicates that more accurate methods of determining fertilizer requirements are needed if sugarcane nutrient needs are to be more accurately met. The objective of our study was to determine the relationship between soil nutrient analyses and sugarcane yields across individual fields for a medium size sugarcane farm in the Teche Region of Louisiana. A soil sample was taken from each of 29 fields where sugarcane variety CP 72-321 was grown in 1993 and analyzed for Ca, Mg, and K (as a % of base saturation), ppm Ca, ppm Mg, ppm K, ppm P, % O.M., pH and CEC. These variables were related to sugarcane yield (T/A) across the 29 fields using a third order multiple correlation model. An R^2 value in excess of 0.85 indicates that the soil nutrient variables had a strong effect on sugarcane yields. The process of relating sugarcane yields to soil analyses is not now complete, but should be ready for presentation at the time of the meetings.

Fallow-Period Legume Contributions to Sugarcane

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This study was conducted to evaluate the effects of fallow-period legume occupation on sugarcane, *Saccharum spp.*, N uptake and yield. Treatments imposed during the fallow period included hairy vetch (VT: *Vicia villosa Roth*), green manure soybeans (GB: *Glycine max* L.), cash soybeans (CB) and a fallow control (FC). Plant-cane N application rates were 0 and 134 kg/ha (FN). All plots in the ratoon crops received recommended N fertilizer rates. The experiment was conducted on soil that is relatively high in organic matter for the region, 2.8%. Total N in topgrowth of VT and GB averaged 151 and 134 kg N/ha. Sugarcane N uptake was not influenced by fallow-period treatments. Nitrogen uptake increased (P=0.07) with FN in the plant cane, but plant-cane yield was not affected. The stalk and sugar yields for all crops of the three-year cycle were not influenced by the presence of the legume crops during the fallow period.

Average cane cycle yields following FC, VT, GB and CB were 7,370, 6,998, 7,152 and 7,132 kg of sugar/ha, respectively. Assignment of N credits to previous legume crops was not possible because yield of unfertilized plant cane following the FC was equivalent to cane receiving FN. The ability of unfertilized plant cane following the FC to yield equivalent to cane benefiting from both additional organic and inorganic N suggests N available from the indigenous soil organic pool in this relatively high-organic-matter soil was sufficient for adequate yields.

Florida Sugarcane Production (1928-1994) and the Importance of Cultivar Development

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Sugarcane in Florida has a historical basis dating to Spanish colonization along the Atlantic Ocean and Gulf of Mexico coastlines to early settlements found in central-south Florida. The sugar industry has grown and prospered adjacent to the southern shores of Lake Okeechobee, beginning in the late 1920's. During this time, acreage under sugarcane production has increased from as little as 700-800 acres in 1928 to over 443,000 acres in 1994. In 1994, the sugar industry ground over 15,000,000 tons of cane and produced nearly 1,800,000 tons of raw sugar. Sugarcane yields have also increased in cane (tons/acre), sugar (tons sugar/acre), and quality (lbs sugar/ton of cane). Mill sugar yield has also improved, increasing from as little as 8.3% during the early 1960s and as high as 11.2% in the 1990s. The reasons for this growth and increase in productivity lie in the past availability of productive farmland, favorable sub-tropical climate, abundant supply of water and rainfall, improvements in technology, greater cultivar diversity, and the continued development of new sugarcane varieties. Between 1970 and 1994, over 27 sugarcane cultivars have been released to the industry, generally replaced by newer cultivars within 10 to 15 years. Cultivar diversity increased from 6 principal cultivars in 1970 to 12 principal cultivars in 1993. Cultivar development and diversity can be recognized as the principal reasons for many observed increases in yield industry-wide and for maintaining resistance to increasing disease and insect pressures resulting in the yield decline. Some cultivars, such as CP 72-1210, are declining in acreage due to increased susceptibility to diseases and resulting decline of yield. This paper will discuss the progressive growth of the Florida sugar industry and the importance of cultivar development and use of new technology.

Sugarcane Response to Water Table Management

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Sugarcane is grown in south Louisiana where rainfall varies considerably both in amount and frequency. At times, usually in the winter and early spring months, rainfall exceeds evapotranspiration several times over, resulting in high water tables that fluctuate near the soil surface. A high water table for prolonged periods causes cane root-rot and reduces soil oxygen which is needed for root growth. At other times, rainfall is less than evapotranspiration, resulting in drought conditions which deter cane growth. A 17-acre field experiment was conducted in Assumption Parish, Louisiana, beginning in 1983, to determine sugarcane response to water-table management. Subsurface drains spaced 50 feet apart were installed approximately three feet below the soil surface on Commerce silt loam soil. The 21 subsurface drain lines were connected to three sumps each equipped with drainage pumps and a water supply which were used for controlling the water-table level in the sumps and the subsurface drain-equipped fields. When drainage was needed, pumps automatically discharged water from the sumps into a surface drain ditch: this lowered the water table in the plots. When irrigation was needed, water was pumped from wells into the sumps: this caused the water level to rise in the sumps and the plots. Sugarcane and sugar yields were measured from the three water managed fields and two similar, nearby fields whose water tables were not managed. The average sugarcane yield (eight crops) with water-table management was 33.41 tons per acre (T/A), which was 2.61 T/A more (8.5%) than that measured from the check areas (no water-table management). The average sugarcane yield from the water-table management treatment was 6817 lbs/A which was 580 lbs/A more (9.3 %) than that measured from the check area. The increase in yield was attributed primarily to the increase in plant population: the average plant population in the water-table management treatment was 8.7% more than that in the check treatment. Although cane and sugar yields were increased by water-table management, the magnitudes of the yield increases were not sufficient to justify the high cost of installing a water-table management system (includes an irrigation well) at 1994 sugar prices.

Sucrose and Reducing Sugars in Stalk Juice of Interspecific Intergeneric Hybrids of Sugarcane

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The wild relatives of sugarcane, which include *Saccharum spontaneum*, *Erianthus*, *Miscanthus*, etc., have many desired traits including disease resistance, tolerance of environmental stresses, ratooning ability and others. They, however, also have undesirable traits including very low sugar level, high fiber, and thin stalk diameter. When we introduce the desired traits into sugarcane through interspecific and intergeneric hybridization, the hybrids usually have lower sucrose content. Information on the levels of sucrose and two reducing sugars, glucose and fructose, of sugarcane and their inheritance would be very useful to breeders. Commercial cultivars, noble canes (*S. officinarum, S. spontaneum, and E. arundinaceum* and their hybrids were used to examine the levels of sucrose and reducing sugars. Crusher juice from mature stalks were analyzed with high performance liquid chromatography (HPLC). Results indicated that commercial cultivars were high in sucrose and were very low in reducing sugars, noble canes were moderate in sucrose levels and low in reducing sugars and both *S. spontaneum* and *E. arundinaceum* had low levels of sucrose and reducing sugars. Hybrids derived from both interspecific and intergeneric crosses had low to moderate levels of sucrose and a wide range of reducing sugar levels. Both commercial cultivars and noble canes accumulated sucrose in cane stalks at higher levels, whereas *S. spontaneum* and *Erianthus* did not build up higher levels of either sucrose or reducing sugars. Both interspecific and intergeneric hybrids showed a marked decrease in the sucrose level from that of the commercial and noble parents. They also had a wide-ranging variation in levels of reducing sugar. Information on the correlation between sucrose and reducing sugars among interspecific and intergeneric hybrids and their offspring should assist breeders in establishing effective breeding and selection programs for using wild germplasm of sugarcane.

Effect of the "Cold Fog" System on Seed Set at Canal Point

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A "cold fog" system was installed in the crossing house at Canal Point in the summer of 1992. The "cold fog" system sprays water under high pressure through atomizing nozzles that breaks the water into very fine droplets (most of which were about 10 microns in diameter.) There are very few water droplets that ever fall so that a true fog is formed. As the fog evaporated, temperatures were reduced and relative humidity increased. Seed set per tassel in the new crossing house, prior to installation of the "cool fog" system, ranged from 73 in the fall of 1990 to 204 in the fall of 1991. Seed set increased to 309 seed/tassel in 1992 the first year the cool fog system was installed.

Sugarcane Borers and Ants on Sandy and Muck Soils in Florida

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Thirty sugarcane fields were sampled for ants, sugarcane borers (SCB), *Diatraea saccharalis* (F) and its parasitoids, on sandy and muck soils in Florida. Infestation by sugarcane borer on both soil types was very low and about equal on both soil types. Sugarcane fields on

muck soils had a mean of 0.02 bored stalks per sample, and on sandy soils a mean of 0.03. Each sample consisted of 25 stalks. Overall, 2.8% of the stalks on sandy fields were bored, while 1.8% of those on muck soils were bored. Only four parasitoids were recovered from SCB larvae, and no adult SCB were caught in pheromone traps. The total number of ants attracted to bait cards was about equal in both soil types; 15,394 on sandy soils, vs 15,025 on muck soils. However, the distribution of six ant species caught in these traps varied between soil types. *Pheidole floridana* Emery was found predominantly on sandy soils, while *Pheidole boubonica* (Forel) was not found in muck soils. The red imported fire ant was the most predominant ant species, and was present in about equal numbers on both soil types.

Baits for Sampling Wireworms in Organic Soils (Histosols) of Southern Florida

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Wireworms are ubiquitous soil insect pests of both vegetable crops and sugarcane grown in southern Florida. Soil insecticides are routinely applied at planting for wireworm control. These routine applications may not always be necessary if low populations of wireworms are present in the fields. However, currently there are few data on sampling wireworms in the organic soils (Histosols) of southern Florida. The objective of our research was to provide data on using baits to sample wireworm populations. During 1991-92, a series of tests was conducted to determine the most attractive bait for wireworms. Tests were conducted in fallow fields. Baits selected for testing were simple (no mixtures), inexpensive, and available year-round since these qualities would make the baits useful to growers. The seven baits tested were apples, carrots, corn ears, corn seed, onions, radishes, rolled oats, and an unbaited control. Each sample consisted of 200 grams of each bait left in the field for 14 days. Tests were conducted in five different fields. Data showed that more wireworms of *Conoderus* spp. and *Melanotus communis* were attracted to rolled oats than any of the other six baits. In addition, rolled oats was the only bait which attracted significantly more wireworms than unbaited samples for both *Conoderus* spp. and *M. communis* ($P<0.05$). During 1992-1993, additional tests were conducted to determine the rate of immigration of wireworms to rolled oat baits. Rolled oat baits (200 grams each) were left in fallow fields for 7, 14, 21, and 28 days. Tests were conducted in 10 different fields. Data showed that more *Conoderus* spp. and *M. communis* were found at baits with increasing time up to 21 days. Thereafter, there were fewer wireworms at baits at 28 days. In addition, it was noted that rolled oat baits are more attractive to *M. communis* wireworms than *Conoderus* spp. Data from these studies show that rolled oats are a simple, attractive bait that may be used for sampling wireworms in the highly organic soils of southern Florida.

Influences of Plot Size on Severity of Sugarcane Rust

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A field experiment was initiated during the 1993/94 growing season to investigate the influence of plot size on the epidemiology of sugarcane rust, caused by *Puccinia melanocephala*.

Six plots, ranging in size from 0.007 ha to 0.418 ha, were planted with the rust-susceptible cultivar CP 72-1210 on October 2, 1993. Plots were separated from each other by a minimum distance of 122 m to minimize interplot interference and were surrounded on all sides by CP 80-1827, a cultivar which is presently rust-resistant. All plots were based on a 2:1 length-to-width ratio, with plot lengths being 12.2, 18.3, 24.4, 30.5, 61.0, and 91.5 m, respectively. Standard 1.5-m row spacing was used, with rows and plot lengths having an east-west orientation. Rust pustules were first observed in the experimental area in late December, the result of an influx of natural air-borne inoculum. Following the initiation of rust epidemics in the respective plots, disease severities were visually assessed on approximately a 14-day schedule by estimating the percent disease on the distal third of 25 randomly selected top-visible-dewlap leaves per plot. Mean rust severities in all plots were below 1% for the January 7, 1994 assessment period. Over time, however, rust severity was significantly influenced by plot size, with mean severities of 3, 8, 11, 12, 18, and 30% being recorded by March 9 for the smallest through largest plots, respectively. Results of these investigations may prove useful in the planning of future rust experiments, varietal screening trials, and in the development of additional control strategies for sugarcane rust.

Preliminary Evaluation and Potential Impact of Leaf Scald on the Louisiana Sugarcane Industry

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Replicated field tests were conducted at Houma, Louisiana and Canal Point, Florida in 1993 to evaluate commercial, advanced candidate, and parental varieties grown in Louisiana for susceptibility to leaf scald caused by *Xanthomonas albilineans.* All varieties were inoculated by the decapitation method with a pure culture of *X. albilineans* isolated at the respective test location. Three assessments were made of each variety in the two tests. First, a rating of 1 to 9 (1 = no visual symptom of infection, 9 = systemic infection with dying plants and/or side shooting) was given to each plot based on the most severely affected stalk in the plot. Second, an overall rating was given to the plot. Third, the percentage of infected stalks, regardless of the severity of the symptoms, was calculated for each plot. Mean plot ratings provided the best evaluation of varietal susceptibility to leaf scald between locations. Among the 10 varieties recommended for planting in Louisiana, five (CP 70-321, CP 76-331, CP 79-318, LHo 83-153, and LCP 85-384) rated resistant in both tests based on plot ratings; the remaining five (CP 74-383, CP 65-357, CP 72-370, LCP 82-89, and HoCP 85-845) rated susceptible or intermediate in at least one test. Sixty-five percent of the advanced candidate varieties (1986 to 1989 breeding series) rated susceptible to moderately susceptible while 75% of the varieties used as parents of selections in the field rated susceptible to moderately susceptible. In addition to varieties identified as susceptible in the inoculated test, 18 of the 79 varieties assigned permanent numbers in 1992 were eliminated from further agronomic testing because of natural infection by *X. albilineans* in Louisiana; and more than 20% of the clones in the first-ratoon and plant-cane crops of the second-line trials (candidates for permanent number assignments in 1993 and 1994, respectively) were also eliminated because of the natural occurrence of leaf scald. Furthermore, approximately 6.4% of seedlings set to the field in 1993 were found infected with *X. albilineans* after apparently becoming infected in the greenhouse. The impact of leaf scald on commercial production of sugarcane and sugar in Louisiana has yet to be determined; however, several commercial fields of CP 74-383 and LCP 82-89 were noted in the Fall of 1993 with more than 20% natural infection. On the other hand, the disease has already had a significant impact on the breeding program with the loss of many advanced candidate and parent varieties.

Worldwide Genetic Variations in the Sugarcane Leaf Scald Disease Pathogen, *Xanthomonas albilineans*

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Outbreaks of leaf scald disease of sugarcane in Florida and Louisiana may have been due to the recent introduction of a distinct genetic variant of the pathogen, *Xanthomonas albilineans*. Two genetically distinct groups among 50 strains from Florida, one representing the original introduction (group 1) and the other (group 2) representing the more recent introduction, were detected by examining restriction fragment length polymorphism (RFLP) of DNA. Similarly, all five strains examined from Louisiana were found to belong to the second group. To analyze polymorphisms, high molecular weight DNA fragments were produced with the rare-cutting restriction enzyme, *Spe 1*, and separated by pulse-field gel electrophoresis. This method is presently being used to examine the genetic variability of strains from throughout the world. To date, 172 strains have been examined, and 159 of the strains can be assigned to one of four genetic groups as follows: 37 strains in group 1 from Australia, Barbados, Dominican Republic, Florida, Hawaii, Madagascar, and Mauritius; 88 strains in group 2 from Barbados, Belize, Brazil, Dominican Republic, Florida, Guadeloupe, Guyana, India, Japan, Louisiana, Martinique, Mauritius, Saint Kitts, Saint Lucia, South Africa, and Taiwan; 18 strains in group 3 from Burkina Faso, Cameroon, Ivory Coast, Malawi, Reunion, Zaire, and Zimbabwe; 19 strains in group 4 from Kenya, Madagascar, Mauritius, Reunion, South Africa, and Zimbabwe. The remaining 13 strains from Argentina, Burkina Faso, Fiji, Guadeloupe, Indonesia, Mauritius, Reunion, and Sri Lanka have not yet been assigned to existing or new groups due to their unusual RFLP patterns. The existence of genetic variants and their limited geographic distribution supports the need for programs to prevent their spread from one country to another.

Changes in Leaf Scald in the Canal Point Sugarcane Variety Development Program in Florida

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The incidence of leaf scald in naturally infected clones in the Canal Point sugarcane development program (Stage II) increased dramatically from 3.4% in 1987 to 15.8% in 1992.

Until 1987, the incidence of leaf scald infection averaged less than 2%. The incidence of infected progeny was influenced by parental clone and year. In 1989, the incidence of infection of progeny ranged from 0 to 50% depending on female parent. Subsequent years had similar ranges. The overall incidence of infection was highest in 1991, based on the infection rate of progeny of CP 81-1827, CP 81-1302, and CP 70-1133 when they were used as either male or female parents in crosses with other clones. Clones that gave rise to high frequencies of leaf scald susceptible progeny have been either discontinued or crossed only with resistant clones in the Canal Point breeding program. The disease has caused many Stage II clones to be eliminated from the program since 1990. A change in the pathogen, *Xanthomonas albilineans*, is suspected.

Evidence for Genetic Transformation of Sugarcane with the Bar Gene

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Embryogenic callus of the variety NCo 310 was bombarded with tungsten particles coated with a plasmid containing the selectable marker *bar* under the control of the maize ubiquitin I promoter. The *bar* gene encodes phosphinothricin acetyltransferase, an enzyme that inhibits the function of some herbicides. Callus selected on medium containing 1 mg/l of bialaphos as a selective agent was transferred to a medium with 3 mg/l of bialaphos where plantlets regenerated. Approximately 1400 rooted plants have been produced and a sample of this population was assayed for the presence of *bar* by *in situ* amplification of specific DNA undergoing the polymerase chain reaction (PCR). Staining with ethidium bromide following gel electrophoresia of the amplified samples suggested that at least one-third of the plants tested are *bar* positive. Our PCR assay gave reproducible results. Southern blot analyses will be conducted to demonstrate the integration of the *bar* gene into sugarcane chromosomal DNA. Gene expression will be measured by physiological and agronomic tests.

Farming Practices Conducive to Elevated Phosphorous Loads in the EAA

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Agricultural drainage water phosphorous (P) concentrations and loads have been monitored for 1.5 years at ten representative farms located across the Everglades Agricultural Area (EAA). Extensive crop and water management data have also been gathered for the experiment farms. Absolute (discharge only), net (inflows and outflows), and unit area loads (UALs) were calculated for the ten sites. Coupling the P loading data with the farm management information lead to the identification of the types of farming systems that have a high potential for discharging elevated levels of P to the area canal network. The four experiment farms including vegetable monocultures, mixed cropping patters (vegetables, sugarcane, etc.), and highly managed water tables produced UALs in excess of 1.0 kg P/ha/yr. Sugarcane monocultures without excessive water table management yielded UALs below 0.5 kg P/ha/yr regardless of size, soil type, and drainage capacities. The development and implementation of P load reduction best management practices (BMPs) for the four sites with high UALs should be fairly straightforward, involving compartmentalizing the farms with respect to crop rotation and water management.

LCP 86-454--A New Sugarcane Variety for Louisiana

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The Louisiana Agricultural Experiment Station of the Louisiana State University Agricultural Center, the Agricultural Research Service of the United States Department of Agriculture, and the American Sugar Cane League of the U.S.A., Inc. working cooperatively to improve sugarcane varieties, have jointly developed and released a new variety, LCP 86-454, for commercial planting in the fall of 1994. LCP 86-454 was selected from progeny of the cross CP 77-310 X CP 69-380. The variety produces moderate populations of large diameter stalks with stalk weights greater than CP 70-321. Results from 89 replicated trials over 7 years and 19 locations indicate that LCP 86-454 sugar and cane yield per area are comparable to CP 65-357, CP 70-321, and CP 74-383. The stalk number per acre is less than that of CP 70-321 in plant cane and similar in stubble crops. The stalk weight of LCP 86-454 is greater than that of the check varieties in all crops. The recoverable sugar content of the variety is similar to CP 65-357 and has a milling factor of 1.035 and a cane fiber content of 12.6%. The variety is suited to mechanical harvesting, with harvesting characteristics similar to CP 72-370 and CP 74-383. LCP 86-454 is resistant to injury caused by the sugarcane borer, *Diatraea saccharalis (F.)*, is resistant to smut (*Ustilago scitaminea* Syd. & P. Syd), moderately resistant to leaf scald (*Xanthomonas albilineans*), susceptible to the sugarcane mosaic virus and susceptible to ratoon stunting disease (*Clavibacter xyll* subsp. xyli). Preliminary data suggest that the variety is tolerant to herbicides used in sugarcane production.

Sugarcane Borer Insecticide Management Studies to Minimize Environmental Pollution

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Toxic runoff in samples on day 3 and 8 for azinphosmethyl (Guthion) are reduced 10 and 100 fold and 10 fold for esfervalerate after 3 days. As concentrations (day 1) for azinphosmethyl approach 13.5 times some LC-50 fish toxicity levels, various insecticide management approaches were undertaken which would mitigate these levels of toxicity. These approaches included (1) alternation of azinphosmethyl application with another insecticide group, (2) mixing a reduced pyrethroid rate (1/3 less) with a 0.14 kg/ha rate acephate, (3) mixing a 1/2 rate of azinphosmethyl with a 1/2 rate of pyrethroid, and (4) several additional cultural measures to insure sufficient dilution before runoff reaches sensitive aquatic areas. This research and development toward labeling will be discussed.

Agriculture and Ecosystem Restoration in South Florida

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South Florida contains a unique mosaic of interconnected wetlands. One historic characteristic of this system of wetlands is the biodiversity it has supported. Signs of ecosystem degradation include increased reports of threatened and endangered species, expansion of invasive non-native species, and oxidation of organic soils. Increased human population from less than one million to more than 4 million is a major reason for this degradation. Agricultural practices in the Everglades Agricultural Area (EAA) have also been implicated to ecosystem degradation. The Secretary of Interior convened a Federal Interagency Task Force which has become the latest among a group of organizations working on restoration of the South Florida Ecosystem. Most of these groups have poor relations with Everglades Agricultural Area (EAA) growers and particularly sugarcane growers because of perceived conflicting goals. This controversy is not warranted if one accepts that sustainable ecosystems must contain sustainable agricultural systems. Ironically, due to its flexible nutrient and water requirements, sugarcane could help resolve many ecological issues in South Florida. The purpose of this presentation is to outline a scientific approach aimed at achieving a profitable, ecologically compatible agriculture in the EAA.

MANUFACTURING ABSTRACTS

Curtailing Bagasse Losses

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Pol losses in bagasse are the second largest of the sugar mill. Far larger than losses in mud filter cake, and than undetermined losses, bagasse losses often account for 25% or more of the total losses incurred in the production of cane sugar. Ergo, any significant reduction of the bagasse losses will at once reflect a sensible increase of the 96 sugar yield. Two factors determine the magnitude of bagasse losses: bagasse fraction in the cane, and pol content of bagasse. While we millwrights can do little, if anything, about the first, since fiber finds its way into the cane in the cane fields, it is on the second where our efforts must be focused. Sugar Cane Growers Cooperative of Florida has consistently been lowering its Percent Pol in Bagasse for four consecutive crops. Down from 3.12, which was average for the five crops from 85-86 through 89-90, the figure has since come to 2.62, 2.50, 2.21, and 1.76, respectively, for the four most recent crops (90-91 through 93-94). That one and one-third percentage point reduction has been instrumental in our East Mill 97.09% all-time Florida record high Sucrose Extraction, final for 93-94 crop, the first time ever a Florida milling train extracted 97% of the Pol in cane, transcending thereby into the domain of diffuser performance, and amounts to more than one quarter of one percent increase of the 96 sugar yield, after the retention our boiling house achieves. Then, given the cane tonnage involved, and the current prices, additional revenue of approximately three million dollars a year, on account of some 7500 extra tons of 96 sugar per crop are recovered, due solely to that one and one-third percentage point. This is just the beginning, though. Greater reduction of bagasse losses in the crops ahead can be fairly envisioned as our 7-year mill improvement progressive program is furthered, and another quarter, or even half percentage point reduction of the pol content of bagasse might entirely be in the realm of possibility. That would bring our mills where only the best amongst the diffusers now are, i.e., bordering 98% Sucrose Extraction, but with the difference in favor of our mills that cane can be mechanically harvested, that no shredding is required, and that a great deal of evaporation is done without. During the first four years of the program, added equipment, improved cane preparation, revised roll settings, and modified components were involved. A discussion on such issues as installments of the integral program, and the lessons taught by these four years are what this paper is all about. Also, a convenient nomograph is offered, for quick estimation of additional sugar and revenue recoverable by any operation through the implementation of the mill improvement program.

Field Soil, Sediment Correction, and Sugar Yield

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At times, sugarcane in Louisiana is delivered to the mill for processing with excessive field soil from the harvesting operation. In the core/press method for predicting the yield of theoretical recoverable sugar per ton of cane (sugar yield) from cane for use in cane payment, approximately 30% of this field soil is extracted with the juice while 70% is retained in the

residue (bagasse). The effect of these solids in the juice is to inflate the juice content of the cane while decreasing the "fiber" (true fiber plus non-cane solids) content of the cane, resulting in an overestimation of the sugar yield. However, adjustments to this overestimation can be made through the use of the sediment correction. Thus, in reality, the total insoluble residue consisting of natural cane fiber, fiber in cane leaves, tops, and other forms of plant material, and field soil should all be considered in calculating total fiber in cane when using the core/press method. In an attempt to quantify the effects of field soil on sugar yield and its components (Brix, sucrose, and fiber % cane), a study was conducted in 1993 where field soil (approximately 32% moisture) was added to clean, unburned, and burned cane of two varieties, CP 65-357 and CP 70-321, taken from the 'heap' row, in increments of 0, 9.09, 16.67, and 23.08% by weight of cane. A fifth treatment consisted of soaking and drip drying samples of clean, unburned, and burned cane of the two varieties in water prior to analyses. This treatment was added to show the possible effects of rainfall on sugar yield and its components. The content of leafy trash in the unburned and burned cane was 2.25 and 1.63%, respectively, for CP 65-357 and 6.08 and 2.52%, respectively, for CP 70-321. The results showed a significant decrease in Brix and sucrose % cane and sugar yield, and an increase in sediment volume and fiber % cane between each incremental increase in the amount of field soil added to clean cane, regardless of the variety. Trash in both the unburned and burned cane further exacerbated the effects of soil on sugar yield by apparently contributing to a greater sediment volume in the juice which resulted in a higher fiber content of cane. Soaking and drip drying of cane caused a reduction in sucrose % cane (4.6, 3.1, and 1.1% in clean, unburned, and burned cane, respectively) and sugar yield (5.3, 3.3, and 1.1% in clean, unburned, and burned cane, respectively) as an average of the two varieties. There was no apparent effect of soaking on fiber content or sediment volume.

Improved Cane Feeding

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Optimizing the cane level in the carriers assures better preparation, increased grinding rates and a uniform feed of cane into the mill which is instrumental in getting better Pol extraction. For the last three crops, at Sugar Cane Growers Cooperative of Florida, the cane level of the cane carriers for both tandems has been controlled by ultrasonic sensors, with a clear advantage over traditional methods of sensing level in the cane carriers. In our quest to improve existing conditions and become more efficient, we took a different approach to control the cane being fed into the mill. This paper describes a method to measure and control the cane level at the chute of the first mill, and includes a report on the results obtained.

New Wear Resistant Technology FO Shredder and Cane Knife Tips

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Historically, sugar factories have been faced with the problems of abrasive wear in the tips of their knives and shredders. Efforts to maintain good preparation throughout the entire grinding season without the problem of wear, have been exhausting. With the tremendous volume of cane to be ground by factories today, the extent of wear on these surfaces has been greatly increased, forcing frequent shutdowns, which in turn seriously affects mill efficiency. The sugar industry has tried with great effort to improve the life of cane knife tips and shredder hammers, with little or no improvement. Although there were some techniques and materials that have proven valuable to the industry, some have not achieved the results that the factories were looking for. By combining an extremely hard white iron casting and a mild steel backing-plate, the properties of these two ordinary materials are exploited to the best of their advantage. Acting alone, these two materials would not be suited for such an application. The white iron casting would be much too brittle, thus reducing its impact resistance. The mild steel, alone, would be much too soft, thus reducing its abrasion resistance. Combined however, with the composite material, each will share the applied load responsibly. Being on the reverse side of the impact surface, the mild steel backing-plate is subject to little if any wear, but plays an important role nevertheless. In the event of an impact severe enough to crack or even shatter the white iron, the mild steel provides the cohesion to hold it together. The significant engineering feature here is the strategic positioning of the steel backing-plate, also, being on the reverse side, the mild steel allows for easy fastening. This can either be done by welding the backing-plate to the swing knife or by using a threaded fastener. If welded, a standard low hydrogen is needed. No heat treating or cooling is necessary. If bolted on, drilling and tapping of the mild steel backing-plate is required. The design of the tip requires enough steel for the correct diameter and depth to hold the tip for maximum wear. By simply loosening the bolt, rotating the tip, and retightening, this greatly reduces downtime. Through a specially-developed vacuum brazing process, the two materials can be joined together to form a laminated composite, with the effective toughness tenfold that of plain white iron. This vacuum brazing process must insure that the properties of the bond zone be approximately the same as the materials being joined. There must also be a continuous attachment of the entire surface, so that the stresses may be effectively transferred. Copper is used as a filler material to insure consistency, followed by a nitrogen quench to achieve maximum hardness. Laminated wear plate, welded or bolted, to the swing hammers of knives and shredders, has proven to be very effective in crushing the efficiency. This white iron/steel composite is a well established and thoroughly proven material, ideally suited for sugarcane preparation applications. After years of use in other industries, guidelines for its successful application in the sugarcane industry are well established. The extraordinary material can be expected to be highly cost effective, as well as solving some acute wear problems in situations where conventional wear materials are not producing an economical result.

Cane Flow Control, Chute Level Controls, and Turbine Protection System in a Milling Tandem Utilizing Special Capacitative Sensors and Electronic Process Controllers

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Miami, Florida

The paper describes integrated systems as are widely applied now in Brazil and other countries which utilize special capacitive sensors with electronic hardware for pre-setting and operating exactly the desired cane level in a mill chute by controlling the cane flow and/or turbine speeds. The system provides for full synchronized automatic control of all cane carriers, high speed belts and turbine speed regulation for any mill as well as turbine overload protection

for shredders and cane knives if so desired. It is particularly used in high cane tonnage tandems utilizing four roll mills with chutes to guarantee a full mill condition for constant float, steady steam supply, better sucrose extraction and bagasse humidity conditions at all times.

Effective Control of Metal Oxide Deposits in Boiler Water Treatment--An Update

James S. Rauh
Midland Research Laboratories, Inc.
Lenexa, Kansas

The occurrence of several tube failures in a high pressure boiler resulted in major changes in their chemical programs and internal inspection methods. In 1991, the chemical treatment program was changed to a phosphate-polymer program utilizing advanced polymer technology for controlling scale, corrosion, and metal oxide deposit problems. Metal oxide deposits which had been measured at greater than 13 gr/m^2 (140 gr/ft^2) were present on waterwall tube samples that were examined. After 24 months on-line, with the new chemical treatment program, the boiler was inspected internally and again found to be in excellent condition. Examination of the boiler, loose deposits, and tube sections removed from the boiler in 1993 showed further evidence of on-line removal of metal oxide deposits and once again supported the decision to not perform an off-line acid cleaning. Additional research and numerous applications of this new chemical treatment program in boilers operating at various pressures have confirmed its ability to perform on-line removal of deposits, including metal oxides. A 350 psig sugar mill boiler in Florida has been on this new program following an off-season acid cleaning due to scaling from a previous chemical program. Results have shown significant removal of additional materials from the boiler during operation through the 1993-94 crop. A review of the operation and results will be covered including photographic documentation of the inspection at the end of the crop.

An Alternative Internal Boiler Water Treatment Chemical Program

Brian Kitchen
Nalco Chemical Company
Kenner, Louisiana

Boilers are extremely critical to the operations of sugar mills. Loss of use can mean a slowdown or virtual shutdown of a mill. There are several options with regard to internal boiler water treatment for sugar mills. The traditional boiler water programs in the industry have been phosphate, phosphate/polymer or chelants. Since newer all-polymer technologies have been developed and used successfully in similar industries, it is generally thought that they may perform in cane mills as well. An all polymer internal boiler water treatment program was run at a Louisiana mill during the 1993 crop. The results of tests and inspections run before, during and after the crop document the success of the transition to the polymer program. The boiler water ran much cleaner with less blowdown, resulting in higher boiler efficiencies and increased steam production. Furthermore, no scale was deposited and a slight clean up of existing scale was actually noted. The paper includes an overview of all-polymer theories vs. phosphate and chelate theories along with boiler cycle chemistry tests, efficiency comparisons, ion transport study tests and photos to document the before and after condition of the boiler internals.

Sulfated Ash vs. Conductimetric Ash in Final Molasses

Edgar L. Aguirre
United States Sugar Corporation
Clewiston, Florida

Sulfated ash is the current analytical method for ash determinations on juices, syrup, final molasses and raw sugars at the Clewiston Sugar House Laboratory, United States Sugar Corporation, Florida. In general, the sulfated ash method involves weighing a given amount of the sample into a platinum dish, adding sulfuric acid, burning the treated sample in a furnace at 550° C for 5 hours, cooling, adding more sulfuric acid, again transferring to the furnace and heating at 550° C for two more hours, cooling in a desiccator and weighing the ash. During the 1992-93 season, a Digital Conductivity meter was bought to evaluate the possibility of using the electrometric method for ash determinations. Weekly composite samples of final molasses from crops 1992-93 and 1993-94 were used for this study. The results obtained from the conductivity meter were then correlated with the sulfated ash. Our comparison study between these two methods showed that the electrometric procedure was faster, simpler, and had greater accuracy than the sulfated method. The details of this study and recommendations are given in this report.

X-Ray Fluorescence Analysis in the Raw Sugar Mill

Monica Fontenot
Audobon Sugar Institute, Louisiana Agricultural Experiment Station
LSU Agricultural Center
Baton Rouge, Louisiana

Jian-Mei Yu
South China Institute of Technology
Guangzhou, China

Stephen J. Clarke
Audobon Sugar Institute, Louisiana Agricultural Experiment Station
LSU Agricultural Center
Baton Rouge, Louisiana

X-Ray fluorescence is a very useful quantitative analysis technique for inorganic elements but there has been limited applications in the sugar industry. Significant advantages are negligible sample preparation and the simultaneous analysis for several elements. The recent acquisition of a bench-top instrument at Audobon Sugar Institute has prompted a study of the applications of this technique. As currently configured, the instrument is set to analyze for potassium, calcium, silicon, phosphorous, sulfur and chlorine. The calibration of the instrument and its application to studies of cane quality, clarification (juice and molasses), evaporator scale, boiling house operations and raw sugar quality will be described. The last is of particular interest since the instrument preferentially measures the surface coating on the crystal.

Journal American Society of Sugar Cane Technologists, Vol. 15, 1995

Mill Improvement Program at St. James Sugar Cooperative, Inc.

Manolo A. Garcia
St. James Sugar Cooperative, Inc.
St. James, Louisiana

Increased milling rates without corresponding mill improvements resulted in lowering of pol extraction at St. James Sugar Cooperative, Inc. To reverse this trend, a mill improvement program was made wherein milling data were collated and analyzed, problem areas identified, possible solutions discussed, and one chosen and implemented. Increased pol extractions were realized and more future improvements are planned.

A Laboratory Study of Double-Effect Evaporator Control

Archibald G. Hill, Sriram Ramamoorthi, and Terence Mendis
Department of Chemical Engineering
University of Southwestern Louisiana
Lafayette, Louisiana

A laboratory double-effect evaporator was used to study alternative control strategies for multiple-effect evaporation. Relative gain analysis of loop variables indicated that the conventional control strategy was not the optimum approach to pairing variables into control loops. Conventional practice pairs final product flow as the manipulated variable used to control product concentration. This requires that liquid level in each evaporator body be controlled by inlet liquid flow. Operation of the laboratory double-effect evaporator confirmed that product concentration could be more efficiently controlled by manipulating liquid flow into the last evaporator body. The laboratory double-effect evaporator is connected to a computer control system including: 1) a Hewlett-Packard measurement and control unit (RTU) having 16 analog inputs, 3 pulse inputs, and 4 analog outputs; and 2) a personal computer with the SCADIX control software package mounted over the Xenix operating system.

Rapid Monitoring of Biological Control in Cooling and Process Systems

Doug Brown, William Cagle, and Stephen Pelham
Grace Dearborn
Norcross, Georgia

Effective microbiological control can be achieved by monitoring microbial levels. The key to measuring the effectiveness of any biocide program is the ability to quickly and accurately measure the microbiological activity in the cooling or process system in real time. This paper will illustrate how a simple, rapid method called Bioscan can be used to control the effectiveness of biocides in open recirculating cooling systems and process systems permitting the optimization of the biocide program. Bioscan provides real time control of microbiological systems within your systems, as well as the suitability of the biocide feed protocol selected.

Journal American Society of Sugar Cane Technologists, Vol. 15, 1995

Increasing Reliability of Sugar Mill Gearing

Art Nelson
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Lufkin, Texas

Machinery reliability is exceptionally important in the Sugar Industry. The typical sugar mill has many gear drives which are used in critical operations. A failure of one of these components during the milling season can cause high cost due to parts replacement and down time. The proposed paper will discuss issues which will give the mill operator and his engineers better knowledge of the factors that will affect the performance of his mill. The mill issues to be covered are:

I. Gear alignment
  A. External
  B. Internal
II. Reduction of gear wear
  A. Basic Analytical Analysis
    1. Rating relative to Durability and Strength
    2. Rating relative to Wear Resistance
  B. Factors which influence wear
    1. Oil Viscosity
      a. Oil Selection
      b. Temperature
    2. Oil Cleanliness
    3. Speed
    4. Load
    5. Tooth Surface Finish
III. External Forces from square Drive Couplings and their effect on gearing
  A. Magnitude
  B. Effect of Forces
  C. How to align gears to mills to reduce these forces

High Horsepower Planetary Gear Boxes for Reduced Cost and Improved Efficiency in Sugar Cane Mill Applications

Saul Herscovici
Power Engineering & Manufacturing, Ltd.
Waterloo, Iowa

The planetary type speed reducing gear box is more adequate for transfer of high torque or high horsepower because there are six pairs of teeth carrying the load simultaneously rather than one pair as is normally the case in a parallel spur or helical reducer, or two pairs as in a herringbone parallel reducer. A planetary that has three planet gears will ensure equal load distribution at the planet to ring gear meshes. This analogy is similar to the three legged stool that will not rock regardless of how uneven the floor may be. This self aligning feature also makes it less sensitive to installation and operating misalignment. Because the planetary output torque is generated by the sum of the forces at six gear meshes, the forces are smaller in magnitude and consequently the entire planetary gear box can be much smaller than a parallel reducer. A planetary gear box may be smaller than half of a parallel reducer, therefore, it can be designed more conservatively to provide a longer life. Perhaps the most important reason to consider a planetary gear box may be that it provides superior performance for a lower price.

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Hydrostatic Drives for Sugarcane Grinding Mills: An Alternative to Traditional Steam Powered Drives

Lou Wendel
Flender Corporation
Marietta, Georgia

Traditional steam powered sugar mill drives, though robust in design, suffer from many deficiencies such as poor efficiency, intense maintenance and limited torque control. Hydrostatic drives, on the other hand, possess the necessary characteristics for a reliable sugar mill drive. This article will take the reader through the evolution of mill drives, discuss the operation and benefits of modern hydrostatic transmissions and present a systematic approach for the successful application of hydrostatic drives on sugarcane grinding mills. Of increasing application is the use of the fourth roll pressure feeder to the mills for increased through-put and greater extraction rates. However, the fourth roll can consume 10-12% of installed turbine horsepower. The incorporation of a dedicated hydraulic drive for the pressure feeder will allow full turbine power to the mill rolls.

Journal American Society of Sugar Cane Technologists, Vol. 15, 1995

AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS
EDITORIAL POLICY

Nature of papers to be published:

Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

Frequency of publication:

The Journal will appear at least once a year. At the direction of the Joint Executive Committee, the Journal may appear more frequently. Contributed papers not presented at a meeting may be reviewed, edited, and published if the editorial criteria are met.

Editorial Committee:

The Editorial Committee shall be composed of the Managing Editor, Technical Editor for the Agricultural Section, and Technical Editor for the Manufacturing Section. The Editorial Committee shall regulate the Journal content and assure its quality. It is charged with the authority necessary to achieve these goals. The Editorial Committee shall determine broad policy. Each editor will serve for three years; and may at the Joint Executive Committee's discretion, serve beyond the expiration of his or her term.

Handling of manuscripts:

Four copies of each manuscript are initially submitted to the Managing Editor. Manuscripts received by the Managing Editor will be assigned a registration number determined serially by the date of receipt. The Managing Editor writes to the one who submitted the paper to inform the author of the receipt of the paper and the registration number which must be used in all correspondence regarding it.

The Technical Editors obtain at least two reviews for each paper from qualified persons. The identities of reviewers must not be revealed to each other nor to the author during the review process. Instructions sent with the papers emphasize the necessity for promptness as well as thoroughness in making the review. Page charges will be assessed for the entire manuscript for non-members. Members will be assessed for those pages in excess of ten (10) double spaced Times New Roman (TT) 12 pt typed pages of 8 1/2" x 11" dimension with one (1) inch margins.

When a paper is returned by reviewers, the Technical Editor evaluates the paper and the recommendations of the reviewers. If the paper as received is recommended by two reviewers for publication in the Journal, it is sent to the Managing Editor. At this time, the Managing Editor will request a final version in hardcopy and on diskette in WordPerfect format from the corresponding author.

If major revisions are recommended, the Technical Editor sends the paper to the author for this purpose, along with anonymous copies of reviewers' recommendations. When the paper is returned to the Technical Editor, he/she will judge the adequacy of the revision and may send the paper back to any reviewer for further review. When the paper has been revised satisfactorily, it is sent to the Managing Editor for publishing. A paper sent to its author for revision and held more than 6 months will be given a new date of receipt when returned. This date will determine the priority of publication of the paper.

A paper rejected by one reviewer may be sent to additional reviewers until two reviewers either accept or reject the paper. If a paper is judged by two or more reviewers as not acceptable for the Journal, theTechnical Editor returns it to the author along with a summary of the reasons given by the reviewers for the rejection. The registration form for the paper is filled out and returned to the Managing Editor along with copies of the reviewers' statements and a copy of the Technical Editor's transmittal letter to the author. The names of all reviewers must be shown on the registration form transmitted to the Managing Editor.

After the review process is completed, each accepted paper is read by the Technical Editor to correct typographical, grammatical, and style errors and to improve the writing where this seems possible and appropriate, with special care not to change the meaning. Instructions for the printer are inserted as needed. The papers are sent by the Technical Editor to the Managing Editor who notifies the authors of this fact and of the probable dates of publication.

Preparation of papers for publication:

Papers sent by the Technical Editor to the Managing Editor are prepared for printing according to their dates of original submittal and final approval and according to the space available in the next issue of the Journal.

The paper is printed in the proper form for reproduction, and proofs are sent to the authors for final review. When the proofs are returned, all necessary corrections are made prior to reproduction. The author will be notified at the appropriate time to order reprints at cost.

Any drawings and photographs for the figures in the paper are "scaled" according to their dimensions, the size of lettering, and other factors. They are then sent to the printer for camera work. Proofs of the illustrations are sent to the authors. Any changes requested at this stage would be expensive and authors will be expected to pay the cost of such changes.

Reprinting in trade journals has the approval of the Editorial Committee provided: a) no article is reprinted before being accepted by the Journal; b) credit is given all authors, the author's institutions, and the ASSCT; and c) permission of all authors has been obtained. Summaries, condensations, or portions may be printed in advance of Journal publication provided the approval of the Editorial Committee has been obtained.

RULES FOR PREPARING PAPERS TO BE PRINTED IN THE JOURNAL OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

Format

Unless the nature of the manuscript prevents, it should include the following sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION (OR RESULTS AND DISCUSSION), CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized. Scientific names shall be italicized.

All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. If using WordPerfect, set the bottom margin at 0.5 inches. This will set the page number at 0.5 inches and the final line of text at 1 inch from the bottom margin. Exactness in reproduction can be insured if electronic copies of the final versions of manuscripts are submitted. Authors are encouraged to contact the managing editor for specifics regarding software and formatting software to achieve ease of electronic transfer.

Authorship

Name of the authors, institution or organization with which they are associated, and their locations should follow the title of the paper.

Abstract

The abstract should be placed at the beginning of the manuscript, immediately following the author's name, organization and location.

Tables

Number the tables consecutively and refer to them in the text as Table 1, Table 2, etc. Each table must have a heading or caption. Capitalize only the initial word and proper names in table headings. Headings and text of tables should be single spaced. Use TAB function rather than SPACE BAR to separate columns of a table.

Figures

Number the figures consecutively and refer to them in the text as Figure 1, Figure 2, etc. Each figure must have a legend. Figures must be of sufficient quality to reproduce legibly.

Drawings & Photographs

Drawings and photographs must be provided separately from the text of the manuscript and identified on the back of each. Type figure numbers and legends on separate pieces of paper with proper identification. Drawings and photographs should be of sufficient quality that they will reproduce legibly.

Reference Citations

The heading for the literature cited should be REFERENCES. References should be arranged such that the literature cited will be numbered consecutively and placed in alphabetical order according to the surname of the senior author. In the text, references to literature cited should be made by name of author(s) and year of publication from list of references. Do not use capital letters in the titles of such articles except in initial words and proper names, but capitalize words in the titles of the periodicals or books.

Format Example

ITCHGRASS *(ROTTBOELLIA COCHINCHINENSIS) CONTROL* IN SUGARCANE WITH POSTEMERGENCE HERBICIDES

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Baton Rouge, LA 70803

and

Edward P. Richard, Jr.
Sugarcane Research Unit, USDA-ARS, Houma, LA 70361

ABSTRACT

INTRODUCTION

MATERIALS AND METHODS

RESULTS AND DISCUSSION

Table 1. Visual itchgrass control and sugarcane injury as influenced by over-the-top herbicide application at Maringouin and Thibodaux, LA, 1989.

CONCLUSIONS

ACKNOWLEDGMENTS

REFERENCES

GUIDELINES FOR PREPARING PAPERS FOR JOURNAL OF ASSCT

The following guidelines for WordPerfect software are intended to facilitate the production of this journal. Authors are strongly encouraged to prepare their final manuscripts with WordPerfect 5.2 for Windows or WordPerfect 6.0 for Windows or Dos. Please contact the Managing Editor if you will not use one of those software packages.

Paper & Margins: All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. To achieve this with WordPerfect, set the top, left, and right margins at one inch. However, set the bottom margin at o.5 inches. This will place the page number at 0.5 inches and the final line of text at one inch.

Fonts: Submit your document in the Times New Roman (TT) 12pt font. If you do not have this font, contact the Managing Editor.

Alignment: Choose the full alignment option to prepare your manuscript. The use of SPACE BAR for alignment is not acceptable. As a general rule SPACE BAR should only be used for space between words and limited other uses. Do not use space bar to indent paragraphs, align and indent columns, or create tables.

Do not use hard returns at the end of sentences within a paragraph. Hard returns are to be used when ending paragraphs or producing a short line.

Place tables and figures within the text where you wish them to appear. Otherwise, all tables and figures will appear after your References section.

Styles: ***Italicize*** scientific names. Do not use underline.

Tables: Use Tab stops or WordPerfect's Tables feature when typing tables. Avoid the space bar to separate columns (see alignment). If you do not use WordPerfect's Tables feature, use the **Graphics** line draw option. This can be used to place lines precisely on the page. All lines should begin with the left most symbol in their left most column and should end with the right most symbol in their right most column.

Citations: When producing Literature Citations, use the indent feature to produce text as below.

1. Smith, I. M., H. P. Jones, C. W. Doe, 1991. The use of multidiscipline approaches to control rodent populations in plants. Journal of American Society of Plant Management. 10:383-394.

Journal American Society of Sugar Cane Technologists, Vol. 15, 1995

CONSTITUTION OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

As Approved on June 16, 1994

ARTICLE I

Name, Object and Domicile

Section 1. The name of this Society shall be the American Society of Sugar Cane Technologists.

Section 2. The object of this Society shall be the general study of the sugar industry in all its various branches and the dissemination of information to the members of the organization through meetings and publications.

Section 3. The domicile of the Society shall be at the office of the General Secretary-Treasurer (as described in Article IV, Section 1).

ARTICLE II

Divisions

The Society shall be composed of two divisions, the Louisiana and the Florida Division. Each division shall have its separate membership roster and separate officers and committees. Voting rights of active and honorary members shall be restricted to their respective divisions, except at the general annual and special meetings of the entire Society, hereinafter provided for, at which general meetings active and honorary members of both divisions shall have the right to vote. Officers and committee members shall be members of and serve the respective divisions from which elected or selected, except the General Secretary-Treasurer who shall serve the entire Society.

ARTICLE III

Membership and Dues

Section 1. There shall be five classes of members: Active, Associate, Honorary, Off-shore or Foreign, and Supporting.

Section 2. Active members shall be individuals residing in the continental United States actually engaged in the production of sugar cane or the manufacture of cane sugar, or research or education pertaining to the industry, including employees of any corporation, firm or other organization which is so engaged.

Section 3. Associate members shall be individuals not actively engaged in the production of sugar cane or the manufacture of cane sugar or research pertaining to the industry, but who may be interested in the objects of the Society.

Section 4. Honorary membership shall be conferred on any individual who has distinguished himself or herself in the sugar industry, and has been elected by a majority vote of the Joint Executive Committee. Honorary membership shall be exempt from dues and entitled to all the privileges of active membership. Each Division may have up to 15 living Honorary Members. In addition, there may be up to 5 living Honorary members assigned to the two Divisions jointly.

Section 5. Off-shore or foreign members shall be individuals not residing in the continental United States who may be interested in the objects of the Society.

Section 6. Supporting members shall be persons engaged in the manufacturing, production or distribution of equipment or supplies used in conjunction with production of sugar cane or cane sugar, or any corporation, firm or other organization engaged in the production of sugar cane or the manufacture of cane sugar, who may be interested in the objects of the Society.

Section 7. Applicants for new membership shall make written application to the Secretary-Treasurer of the respective divisions, endorsed by two members of the division, and such applications shall be acted upon by the division membership committee.

Section 8. Annual dues shall be as follows:

Dues for each calendar year shall be paid not later than 3 months prior to the annual meeting of the member's division. New members shall pay the full amount of dues, irrespective of when they join.

Section 9. Dues shall be collected by each of the Division Secretary-Treasurers from the members in their respective divisions.

Section 10. Members in arrears for dues for more than a year will be dropped from membership after 30 days notice to this effect from the Secretary-Treasurer. Members thus dropped may be reinstated only after payment of back dues and assessments.

Section 11. Only active members of the Society whose dues are not in arrears and honorary members shall have the privilege of voting and holding office. Only members (all classes) shall have the privilege of speaking at meetings of the Society.

ARTICLE IV

General Secretary-Treasurer and Joint Executive Committee

Section 1. The General Secretary-Treasurer shall serve as Chief Administrative Officer of the Society and shall coordinate the activities of the divisions and the sections. He or she will serve as ex-officio Chairperson of the Joint Executive Committee and as General Chairperson of the General Society Meetings, and shall have such other duties as may be delegated to him or her by the Joint Executive Committee. The office of the General Secretary-Treasurer shall be the domicile of the Society.

Section 2. The Joint Executive Committee shall be composed of the members of the two division Executive Committees, and is vested with full authority to conduct the business and affairs of the Society.

ARTICLE V

Division Officers and Executive Committee

Section 1. The officers of each division of the Society shall be: a President, a First Vice-President, a Second Vice-President, a Secretary-Treasurer, and an Executive Committee composed of these offices and four other members, one from each section of the Division (as described in Section 3 of Article VII), one elected at large, and the President of the previous Executive Committee who shall serve as an Ex-Officio member of the Division Executive Committee.

Section 2. These officers, except Secretary-Treasurer, shall be nominated by a nominating committee and voted upon before the annual division meeting. Notices of such nominations shall be mailed to each member at least one month before such meeting. Ballots not received before the annually specified date will not be counted.

Section 3. The Secretary-Treasurer shall be appointed by and serve at the pleasure of the Division Executive Committee. The Secretary-Treasurer may not hold an elected office on the Executive Committee.

Section 4. The duties of these officers shall be such as usually pertain to such officers in similar societies.

Section 5. Each section as described in Article VII shall be represented in the offices of the President and Vice-President.

Section 6. The President, First Vice-President, and Second Vice-President of each Division shall not hold the same office for two consecutive years. Either Section Chairperson (as described in Section 3 of Article VII) may hold the same office for up to two consecutive years. The terms of the other officers shall be unlimited.

Section 7. The President shall be elected each year alternately from the two sections hereinafter provided for. In any given year, the Presidents of the two Divisions shall be nominated and elected from different sections. The President from the Louisiana Division for the year beginning February, 1970, shall be nominated and elected from the Agricultural Section. The President from the Florida Division for the year beginning February, 1970, shall be nominated and elected from the Manufacturing Section.

Section 8. Vacancies occurring between meetings shall be filled by the Division Executive Committee.

Section 9. The terms "year" and "consecutive year" as used in Articles V and VI shall be considered to be comprised of the elapsed time between one annual division meeting of the Society and the following annual division meeting of the Society.

ARTICLE VI

Division Committees

Section 1. The President of each division shall appoint a committee of three to serve as a Membership Committee. It will be the duty of this committee to pass upon applications for membership in the division and report to the Secretary-Treasurer.

Section 2. The President of each division shall appoint each year a committee of three to serve as a Nominating Committee. It will be the duty of the Secretary-Treasurer of the

Division to notify all active and honorary members of the Division as to the personnel of this committee. It will be the duty of this committee to receive nominations and to prepare a list of nominees and mail this to each member of the Division at least a month before the annual meeting.

ARTICLE VII

Sections

Section 1. There shall be two sections of each Division, to be designated as:

1. Agricultural
2. Manufacturing

Section 2. Each active member shall designate whether he or she desires to be enrolled in the Agricultural Section or the Manufacturing Section.

Section 3. There shall be a Chairperson for each section of each Division who will be the member from that Section elected to the Executive Committee. It will be the duty of the Chairperson of a section to arrange the program for the annual Division meeting.

Section 4. The Executive Committee of each Division is empowered to elect one of their own number or to appoint another person to handle the details of printing, proof reading, etc., in connection with these programs and to authorize the Secretary-Treasurer to make whatever payments may be necessary for same.

ARTICLE VIII

Meetings

Section 1. The annual General Meeting of the members of the Society shall be held in June each year on a date and at a place to be determined, from time to time, by the Joint Executive Committee. At all meetings of the two Divisions of the Society, 5% of the active members shall constitute a quorum. The program for the annual meeting of the Society shall be arranged by the General Secretary-Treasurer in collaboration with the Joint Executive Committee.

Section 2. The annual meeting of the Louisiana Division shall be held in February of each year, at such times as the Executive Committee of the Division shall decide. The annual meeting of the Florida Division shall be held in September or October of each year, at such time as the Executive Committee of that Division shall decide. Special meetings of a Division may be called by the Executive Committee of such Division.

Section 3. Special meetings of a Section for the discussion of matters of particular interest to that Section may be called by the President upon request from the respective Chairperson of a Section.

Section 4. At Division meetings, 10% of the active division members and the President or a Vice-President shall constitute a quorum.

ARTICLE IX

Management

Section 1. The conduct and management of the affairs of the Society and of the Divisions including the direction of work of its special committees, shall be in the hands of the Joint Executive Committee and Division Executive Committees, respectively.

Section 2. The Joint Executive Committees shall represent this Society in conferences with the American Sugar Cane League, the Florida Sugar Cane League, or any other association, and may make any rules or conduct any business not in conflict with this Constitution.

Section 3. Four members of the Division Executive Committee shall constitute a quorum. The President, or in his or her absence one of the Vice-Presidents, shall chair this committee.

Section 4. Two members of each Division Executive Committee shall constitute a quorum of all members of the Joint Executive Committee. Each member of the Joint Executive Committee, except the General Secretary-Treasurer, shall be entitled to one vote on all matters voted upon by the Joint Executive Committee. In case of a tie vote, the General Secretary-Treasurer shall cast the deciding vote.

ARTICLE X

Publications

Section 1. The name of the official journal of the Society shall be the "Journal of the American Society of Sugar Cane Technologists." This journal shall be published at least once per calendar year. All articles, whether volunteered or invited, shall be subject to review as described in Section 4 of Article X.

Section 2. The Managing Editor of the Journal of the American Society of Sugar Cane Technologists shall be a member of either the Florida or Louisiana Divisions; however, he or she shall not be a member of both Divisions. The Division affiliation of Managing Editors shall alternate between the Divisions from term to term with the normal term being 3 years, unless the Division responsible for nominating the new Managing Editor reports that it has no suitable candidate. The Managing Editor shall be appointed by the Joint Executive Committee no later than 6 months prior to the beginning of his or her term. A term will coincide with the date of the annual Joint Meeting of the Society. No one shall serve two consecutive terms unless there is no suitable candidate from either Division willing to replace the current Managing Editor. If the Managing Editor serves less than one year of his or her 3-year term, another candidate is nominated by the same Division, approved by the other Division, and appointed by the General Secretary-Treasurer to a full 3-year term. If the appointed Managing Editor serves more than 1 year but less than the full 3-year term, the Technical Editor from the same Division will fill the unexpired term of the departed Managing Editor. In the event that the Technical Editor declines the nomination, the General-Secretary-Treasurer will appoint a Managing Editor from the same Division to serve the unexpired term.

Section 3. The "Journal of the American Society of Sugar Cane Technologists" shall have two Technical Editors, which are an Agricultural Editor and a Manufacturing Editor. The Managing Editor shall appoint the Technical Editors for terms not to exceed his or her term of office. Any Technical Editor shall be a member of either the Louisiana or Florida Division. Each Division will be represented by one Technical Editor at all times unless the Executive Committee of one Division and the Managing Editor agree that there is no suitable candidate willing to serve from that Division.

Section 4. Any member or nonmember wishing to contribute to the Journal of the American Society of Sugar Cane Technologists shall submit his or her manuscript to the Managing Editor. The Managing Editor shall then assign the manuscript to the appropriate Technical Editor. The Technical Editor shall solicit peer reviews until, in the opinion of the Technical Editor, two responsible reviews have been obtained that either accept (with or without major or minor revision) or reject the manuscript. For articles accepted with major revision, it shall be the responsibility of the Technical Editor to decide if the authors have satisfactorily completed the major revision(s). The Technical Editor may solicit the opinion of the reviewers when making this decision. The Technical Editors shall not divulge the identity of any reviewer. The Managing Editor shall serve as Technical Editor of any manuscript which includes a Technical Editor as an author.

ARTICLE XI

Amendments

Section 1. Amendments to this Constitution may be made only at the annual meeting of the Society or at a special meeting of the Society. Written notices of such proposed amendments, accompanied by the signature of at least twenty (20) active or honorary members must be given to the General Secretary-Treasurer at least thirty (30) days before the date of the meeting, and he or she must notify each member of the proposed amendment before the date of the meeting.

ARTICLE XII

Dissolution

Section 1. All members must receive notification from the General Secretary-Treasurer of any meeting called for the purpose of terminating the Society at least thirty (30) days prior to the date of the meeting. After all members have been properly notified, this organization may be terminated at any time, at any regular or special meeting called for that purpose, by an affirmative vote of two-thirds of the total honorary and active members in good standing present at the meeting. Thereupon, the organization shall be dissolved by such legal proceedings as are provided by law. Upon dissolution of the Joint Society, its assets will be divided equally between the two Divisions of the Society. Dissolution of the Joint Society will not be cause for automatic dissolution of either Division. Upon dissolution of either Division, its assets will be divided in accordance with the wishes of its members and in conformity with existing IRS regulations and other laws applicable at the time of dissolution.

ARTICLE XIII

Assets

Section 1. No member shall have any vested right, interest or privilege of, in, or to the assets, functions, affairs or franchises of the organization; nor any right, interest or privilege which may be transferable or inheritable.

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